A CATALOGUE OF *CLADOPHORA* CONTAMINANT DATA FOR THE GREAT LAKES AND INTERCONNECTING CHANNELS, 1981 - 1989

VOLUME I - METALS

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VOLUME I - METALS

Report prepared by:

T. Hollister
H. Vandermeulen
M. Jackson
A. Rodrigues
Limnology Section
Water Resources Branch

PREFACE

Cladophora is a genus of the class Chlorophyceae (green algae) that grows attached to solid substrates as a branched macroscopic thallus. *Cladophora* cells accumulate contaminants (certain metals and synthetic organic compounds) from the surrounding water, even when the aqueous concentrations are very low. *Cladophora* is therefore an excellent biomonitor of contaminants in water, especially at locations where inputs of contaminants may be at chronic low levels or where significant concentrations occur only after intermittent pulse inputs. *Cladophora* integrates these exposures over time so that the contaminant content of this alga is a good measure of the "average" contaminant levels in the ambient water. Regular and long term measurements of *Cladophora* contaminant levels may be one of the best ways of tracking long term trends in certain contaminants, especially at locations where conventional water sampling cannot detect low concentrations and might miss intermittent inputs resulting from spills, illegal discharges, or other irregular inputs determined by weather events.

The information presented in this data report should be utilized for general information only and not as a source for rigorous numerical comparisons. The data are often highly variable from year-to-year and comparisons should be made with caution. The variability in the *Cladophora* contaminant data is likely a result of the growth rate of the plants prior to collection, the age of the plants collected, previous spill events (a short term pulse of contaminants), long term changes in contaminant loading and the sample collection location (Oertel 1991). Variability could be controlled somewhat in future studies by using "clean" laboratory grown plants of uniform age and growth rate outplanted to field sites for contaminant uptake. Part II of this report (Hollister et al. 1993) includes selected chlorinated organic compounds and pesticides concentrations.

ACKNOWLEDGEMENTS

Ken Nicholls kept the *Cladophora* contaminant program alive during staffing shortages. His discussion sessions and advice have helped to direct this work from the start. The author also gratefully acknowledge the work of Frank Armstrong who assisted with the tables and figures, and the efforts of the Inorganic Trace Contaminants Section of the Ministry of Environment and Energy's Laboratory Services Branch, in the analyses of these samples.

Note: All references to Ministry of the Environment in this report should read Ministry of Environment and Energy.

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INTRODUCTION

Cladophora glomerata (L.) Kütz is a freshwater green alga with a wide distribution in the lower Great Lakes. It is a benthic alga, a member of the periphyton, which forms elongated cord-like thalli that are light to dark emerald green in color. Typical thalli growing under favourable conditions are 30 cm long or more. *Cladophora* requires a hard substratum for attachment and growth. The plants can form very dense populations just under the surface which extend for kilometres along rocky shores. An excellent summary of the autecology of *Cladophora* is provided by Dodds (1991).

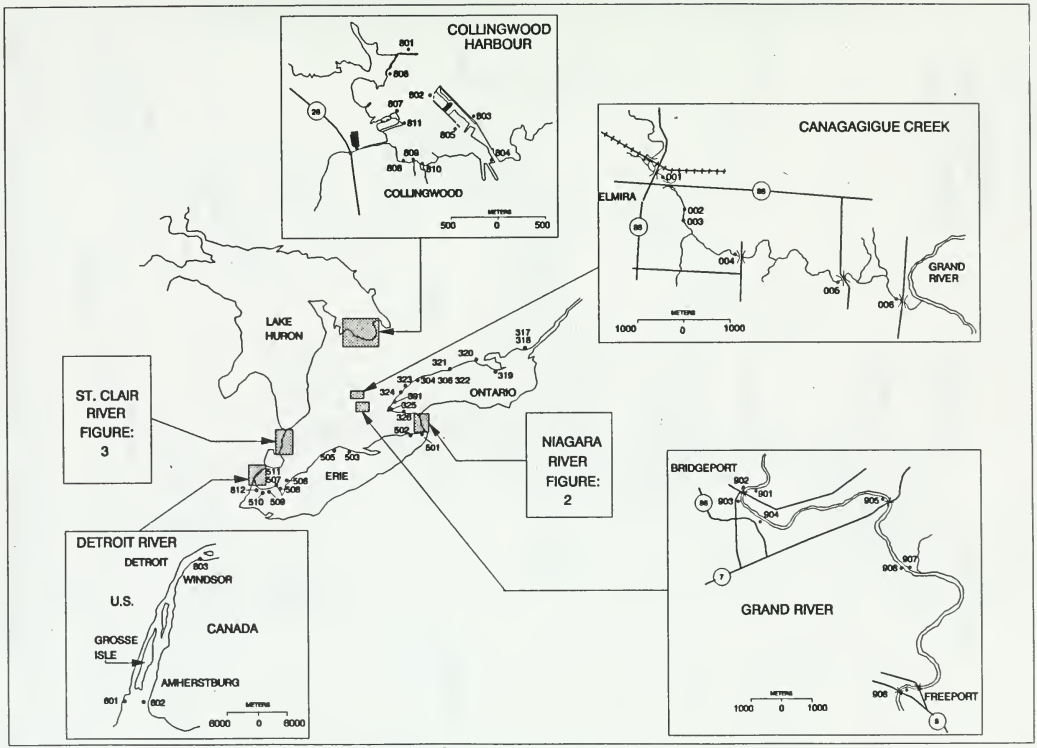
Cladophora has been widely used to monitor contaminants in surface waters. Field studies have been performed in Europe (McLean 1974, Larsson 1987, Whitton et al. 1989, Oertel 1991) and in the Great Lakes area (Burkett 1973, Keeney et al. 1976, Wells et al. 1980, Anderson et al. 1982, MOE 1982, Jackson 1988, Jackson et al. 1990, MOE 1991). Laboratory studies have explored the growth effects, physiology and mode of contaminant uptake in *Cladophora* species (Whitton 1970, Williams 1970, Burkett 1975, Schanz & Thomas 1978, Sivalingam & Ismail 1981, Sivalingam & Ismail 1982, Vymazal 1990).

Cladophora is well established as a biomonitoring tool. This publication is a data report which summarizes a decade of *Cladophora* contaminant sampling in southern Ontario. As a data report there is no extensive interpretation of results. The report format is designed for perusing the data and drawing the readers attention to information or sites that require more study. The data presented herein should not be used for contaminant loading calculations or detailed comparisons between sites.

MATERIALS AND METHODS

Cladophora samples were collected from Collingwood Harbour, the St. Clair River, the Detroit River, Lake Erie, the Niagara River, Lake Ontario, Canagagigue Creek and the Grand River at the sample sites shown in Figures 1-3 and described in Tables 1-8. Samples were collected for determination of internal concentrations of elements and organic compounds from 1981 to 1989, during June and July, when *Cladophora* biomass was at its peak. Approximately 1 kg wet weight of algae was collected at each site. This was then washed with ambient water to remove silt and debris, squeezed dry, wrapped in absorbent paper and transported on ice to the MOE laboratory in Rexdale, Ontario. The samples were then frozen to -50°C, dried, ground and sub-sampled for analysis in triplicate. From 1981-1985 samples were dried to a constant weight at 50°C prior to analysis, while from 1986-1989 samples were freeze dried using no tray heating. Analysis indicated no discernable difference between the two drying methods (MOE unpublished data, 1990). All chemical analyses were performed following the "Handbook of Analytical Methods for Environmental Samples" (MOE 1983).

In the following results, the lowest reportable value (LRV) represents the value below which there was no analytical response, while the reliable measurable value (RMV) represents the value below which the analytical result was considered somewhat unreliable due to imprecision or bias, as defined by the MOE, Laboratory Services Branch, Quality Assurance Policy and Guidelines. LRVs were treated as '0' in calculations. Although this sometimes biased the results, so that reported values were smaller than actual values, it was felt that this would be the best way to treat them. Reported values between the LRV and the RMV were treated as actual values. Although these values were not considered entirely reliable by the lab they were used for two reasons; a) in the past the laboratory did not differentiate between 'normal' values and these 'trace' values. b) under the circumstances, it was the best available value. If all values in a calculation were LRVs, the sample was said to be Below Detection (BD). Some of the results for calcium and potassium were possibly larger than indicated values. Due to analysis problems a more accurate figure was not available. These questionable results are noted where applicable.



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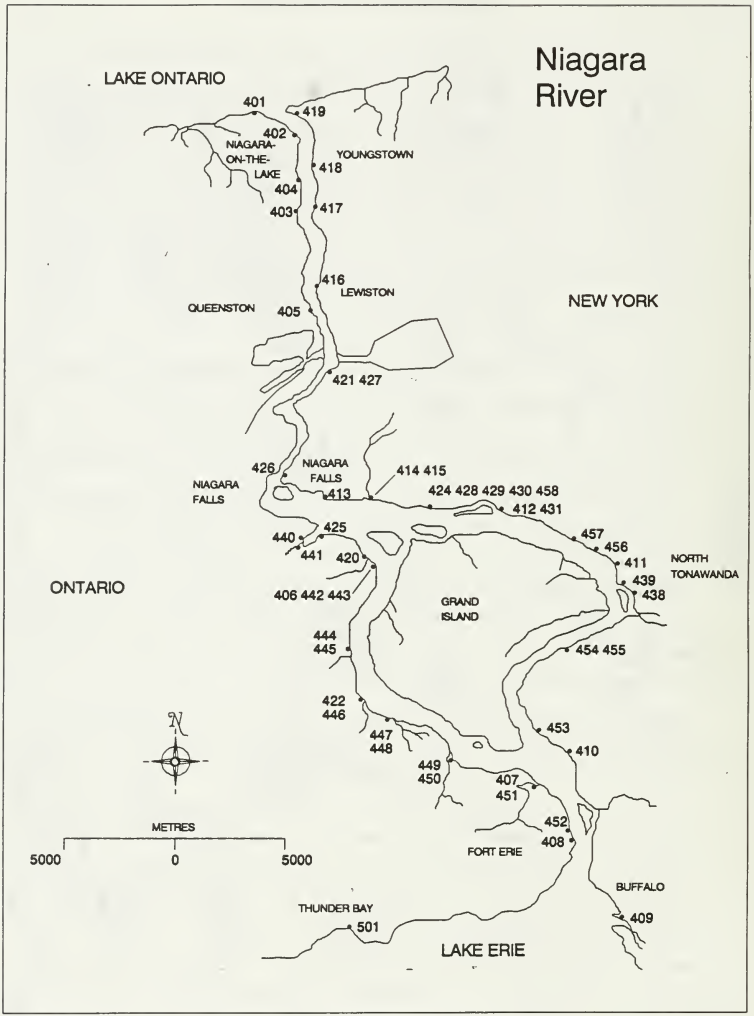

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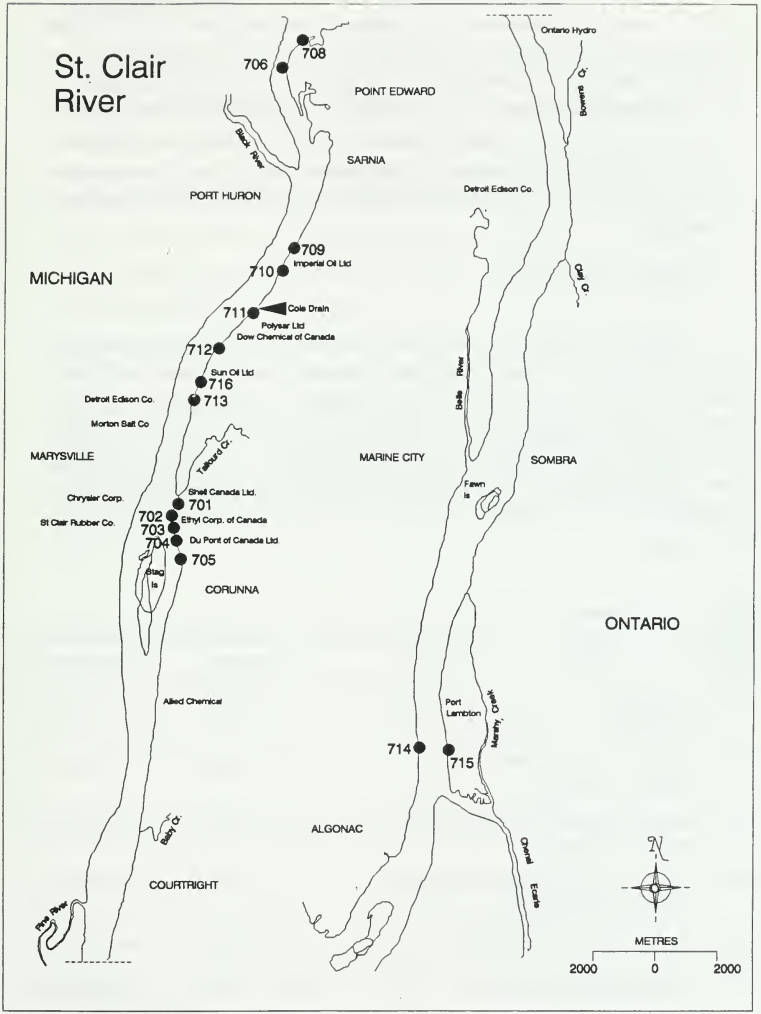

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It should be noted that there were a number of reasons why there were no results at some sample locations; due to technical problems in the field or at the lab, not all samples were collected or analyzed as planned, while at some sites there were insufficient amounts of *Cladophora* for a complete or even partial analysis. The minimal availability of samples at these sites could reflect locally toxic conditions. The values reported are the averages of the samples, which were analyzed in triplicate. An example of the standard deviation for these averages can be found in Appendices I and II (stations 415 and 402), which have respectively high and low concentrations of contaminants.

Canagagigue Creek, 001 Series

Cladophora samples were collected from shoreline sites along Canagagigue Creek, on May 12 (stations 001-006), 21 (stations 001-003, 005 and 006) and 26 (stations 001, 002 and 006), 1987 (Table 1). Samples were not obtained on all dates at the sites indicated earlier because *Cladophora* was no longer abundant, or as in the case of Site 004, macrophytes had taken over the area. To facilitate comparison between sites, only data for May 12 has been graphed (Figs. Can.1-Can.4), as this appeared to be when *Cladophora* growth was at its peak and the only date all sites were sampled.

Table 1: Canagagigue Creek Stations

Station	Location	Latitude	Longitude
001	Upstream, at the park just north of the bridge	43° 35' 00.00"	80° 35' 00.00"
002	100m upstream of overflow sewer, opposite Uniroyal	43° 35' 00.00"	80° 35' 00.00"
003	25m downstream of overflow sewer, on east side of creek	43° 35' 00.00"	80° 35' 00.00"
004	80m upstream of bridge #1, adjacent to Federal Gauge Stn.	43° 34' 00.00"	80° 33' 00.00"
005	50m upstream of bridge #2	43° 34' 00.00"	80° 31' 00.00"
006	25m upstream of bridge #3	43° 34' 00.00"	80° 30' 00.00"

Cladophora samples were collected from shoreline sites along Lake Ontario from 1981-1989 at 13 sites (Table 2). In 1981, *Cladophora* samples were collected on June 16-18 at sites 304 and 317-326. These same sites were sampled on July 22, 23 and 25, with the exception of site 323. On August 17-21, sites 304, 318, 319, 321, 322 and 324-326 were also sampled. June 16 and 17 were chosen to be representative of the 1981 data for graphing purposes (Figs. Ont.1-Ont.2), since this is when peak biomass occurred and when most of the sites were sampled.

From 1982-1984, *Cladophora* samples were collected at sites 304, 317, 319, 321, 322 and 324-326, with the exception of 318 which was added in 1982, and the time trend data collected from May 30 to Aug 29, 1983 at station 391 (Fig. Ont.3). In 1985, *Cladophora* samples were collected at the same sites as 1984, with the addition of site 306. The only data collected in 1986-1989 was at site 319, which has been presented as a time trend from 1981-1989 in Figure Ont.3.

Table 2: Lake Ontario Stations

Station	Location	Latitude	Longitude
304	Humber River (mouth), west shore at point opposite condominium	43° 37' 57.96"	79° 28' 30.95"
306	Ontario Place lake	43° 37' 07.00"	79° 25' 05.00"
317	Cataraqui River (mouth), east shore opposite historical fort	44° 13' 04.07"	76° 32' 23.12"
318	Cataraqui R. (upstream), at Kingston bridge by Royal Military College	44° 13' 04.07"	76° 32' 23.13"
319	Prince Edward County (Owen Pt.), at exposed point of land	43° 53' 41.41"	77° 16' 42.32"
320	Trent River (mouth), partially exposed east shore opposite park	44° 06' 00.51"	77° 34' 25.10"
321	Ganaraska R. (mouth), at exposed breakwall bordering beach	43° 56' 37.61"	78° 17' 00.96"
322	Toronto Harbour East Gap, exposed eastern shore at south point	43° 37' 51.77"	79° 21' 04.86"
323	Aquitaine Lake, along eastern shore	43° 37' 34.46"	79° 40' 25.49"
324	Credit R. (mouth), exposed western breakwall (forming river channel)	43° 33' 11.47"	79° 35' 19.29"
325	Hamilton Harbour ship canal (mouth), shoreline 50m south of canal breakwall	43° 18' 12.20"	79° 47' 30.29"
326	Twelve Mile Creek (mouth), exposed shore 25m east of creek breakwall	43° 12' 23.60"	79° 15' 51.68"
350	Point Petre (offshore), offshore to the right of lighthouse	43° 50' 19.14"	77° 09' 00.00"
374	Point Petre (shoreline), end of dirt road on right prior to the lighthouse	43° 50' 19.14"	77° 09' 00.00"
391	Oakville (Park Ave.), east of Oakville Creek	43° 27' 21.48"	79° 44' 43.63"

Cladophora samples were collected from shoreline sites along the Niagara River from 1981-1989 at 52 sites, including the control at site 501 (Table 3). In 1981, *Cladophora* samples were collected on June 18 and 19 at sites 401-419, with the exception of station 408, 414 and 415, on July 23 and 24 for sites 401-407, 409-412 and 415-419, and on Aug 18 and 19 at sites 401, 402, 405-407, 410-412 and 414-419. June 18 and 19 were chosen to be representative of the 1981 data, since this was when peak biomass occurred. In 1982, *Cladophora* samples were collected on June 22, 23 and 24 from sites 401-405, 407, 409-413 and 415-420, and on July 17 at station 421. At site 407, two separate samples were collected, so the results for the two were averaged on the graphs presented in Figures Niag.1-Niag.4. In 1983, samples were collected on June 28 and 29 at sites 402, 406, 408, 412-415, 421 and 424-431.

In 1984, *Cladophora* samples were collected on June 28 and 29 at sites 402, 406-408, 410-413, 415 and 421. In 1985, samples were collected on June 25 and 26 at the same sites as 1984, with the addition of site 451. In 1986, *Cladophora* samples were only collected at site 402. In 1987, samples were collected on June 17 and 18 at the same sites as the 1985 samples, with the following exceptions: no sample was collected at site 406 and sites 414, 422, 429, and 438-458 were added. In 1988 and 1989, *Cladophora* samples were collected at sites 402, 406, 408, 410-412, 415 and 451. There were an additional 3 sites for 1988 at sites 413, 421 and 453.

Table 3: Niagara River Stations

Station	Location	Latitude	Longitude
401	Niagara-On-The-Lake, at Fort Mississauga	43° 15' 59.40"	79° 04' 18.02"
402	Fort George, just south of the dock	43° 14' 53.86"	79° 03' 35.75"
403	Inniskillin Rd., follow path down to river	43° 13' 49.06"	79° 03' 37.81"
404	St. Catharines Boat Club, to the south of the walkway	43° 13' 16.66"	79° 03' 38.83"
405	Queenston, Sand Co. lot off Dumfries St.	43° 10' 01.89"	79° 03' 22.86"
406	Navy Is., 100m south of the mouth of Ussher's Creek	43° 02' 25.26"	79° 00' 40.52"
407	Frenchman's Creek (mouth), 1st car park north of creek	42° 58' 06.07"	79° 00' 48.88"
408	Fort Erie, north of Peace Bridge at park by sand beach	42° 55' 50.20"	78° 55' 00.33"
409	Buffalo River (upstream), at marina at Coast Guard Rd.	42° 52' 33.39"	78° 52' 54.74"
410	At lighthouse on American shore	42° 56' 54.19"	78° 54' 14.05"
411	Tonawanda, north of Fishman Park west side of creek	43° 02' 17.35"	78° 53' 18.86"
412	Love Canal, south end of Griffon Park, opposite the dump	43° 04' 30.96"	78° 56' 55.37"
413	Dupont-Landfill North, 300m east of water treatment plant	43° 04' 51.82"	79° 01' 20.00"
414	Dupont-Above Sewer/Gill Creek, the north side of creek	43° 04' 51.82"	79° 01' 20.00"
415	Dupont-Below Gill Creek, south side of creek	43° 04' 51.82"	79° 01' 20.00"
416	Lewiston, just south of Riverside Park	43° 10' 33.91"	79° 02' 59.70"

Table 3: cont.

Station	Location	Latitude	Longitude
417	SCA Discharge, at Joseph Davis State Park	43° 13' 16.28"	79° 03' 16.68"
418	Youngstown, near green duck hunting hut at #3663 Duncan	43° 14' 21.08"	79° 03' 14.62"
419	Fort Niagara, at public boat launch	43° 15' 42.83"	79° 03' 56.37"
420	Ussher's Creek (mouth), at the mouth of creek	43° 02' 58.43"	79° 01' 23.65"
421	Bloody Run Creek (mouth), 10-20m south of power plant fence	43° 08' 07.36"	79° 02' 20.10"
422	Black Creek (mouth), adjacent to bridge on the north bank	43° 59' 49.83"	79° 01' 14.43"
424	53rd St. Dock, under transmission line #2, north of public dock	43° 04' 49.51"	78° 59' 07.41"
425	Welland River	43° 03' 56.75"	79° 01' 21.77"
426	American Falls	43° 05' 10.67"	79° 03' 54.19"
427	Bloody Run Creek (upstream), 10-20m south of power plant fence	43° 08' 07.36"	79° 02' 20.10"
428	S/N Area North, directly under 1st transmission line north of bridge	43° 04' 49.51"	78° 59' 07.41"
429	Occidental 003 Sewer (mouth), downstream of stone building	43° 04' 49.51"	78° 59' 07.41"
430	S/N Area South, right at the edge of power intake cement wall	43° 04' 49.51"	78° 58' 07.41"
431	Love Canal (South Bay), south end of Griffon Park, opposite the dump	43° 04' 26.93"	78° 53' 14.41"
438	Pettit Flume (control), 70-100m upstream of flume mouth	43° 02' 01.00"	78° 53' 02.00"

Table 3: cont.

Station	Location	Latitude	Longitude
439	Pettit Flume (mouth), north bank opposite the Offtrack Betting Shop	43° 02' 01.00"	78° 53' 02.00"
440	Pell Creek, 30m upstream at Front and Daley St.	43° 03' 20.00"	79° 03' 30.00"
441	Lyons Creek, 50m upstream of hwy bridge	43° 03' 00.00"	79° 03' 50.00"
442	Ussher's Creek (control), 100m south of creek mouth	43° 02' 58.00"	79° 01' 23.65"
443	Ussher's Creek (upstream), 100m upstream of creek mouth	43° 02' 58.43"	79° 01' 23.65"
444	Boyer's Creek (mouth), at mouth of Boyer's Creek	43° 00' 08.00"	79° 01' 50.00"
445	Boyer's Creek (control), 300m upstream of creek mouth	43° 00' 08.00"	79° 01' 50.00"
446	Black Creek (control), 200m upstream of creek mouth	42° 59' 49.83"	79° 01' 14.43"
447	Baker Creek (mouth), at the far end of the car park	42° 58' 22.00"	79° 00' 23.00"
448	Baker Creek (control), 150m upstream of creek mouth	42° 58' 22.00"	79° 00' 23.00"
449	Miller Creek (mouth), at the mouth of Miller Creek	42° 57' 20.00"	78° 58' 25.00"
450	Miller Creek (control), upstream of creek mouth	42° 57' 20.00"	78° 58' 25.00"
451	Frenchman's Creek (control), north side of the mouth of the creek	42° 58' 06.07"	79° 00' 48.88"
452	Fort Erie, south side of beach, at park, north of Peace Bridge	42° 53' 05.00"	78° 56' 32.00"

Table 3: cont.

Station	Location	Latitude	Longitude
453	Black Rock Canal, at outflow channel, opposite pumping station	42° 56' 54.19"	78° 54' 14.05"
454	2 Mile Creek (mouth), north bank at mouth of creek	43° 00' 40.00"	78° 54' 19.00"
455	2 Mile Creek (control), 220m upstream of snack bar	43° 00' 40.00"	78° 54' 19.00"
456	Gratwick Riverside Park, north end of landfill at end of park	43° 02' 50.00"	78° 53' 35.00"
457	Wheatfield, at old pilings at the end of the path beside river	43° 02' 58.00"	78° 53' 35.00"
458	Occidental 003 Sewer (control), downstream of stone building	43° 04' 49.51"	78° 59' 07.41"

Lake Erie, 500 Series

Cladophora samples were collected from the shoreline of Lake Erie at sites indicated in Table 4. Site 501 was the only sample collected on June 18, July 23 and Aug 19 1981, June 23 1982, June 28 1983, June 27 1984, June 25 1985, July 3 1986, June 17 1987 and July 4 1989. In 1988 collections were made on June 15 at sites 503 and 505-510, on June 16 at site 502, and on June 22 at sites 501 and 511.

Table 4: Lake Erie Stations

Station	Location	Latitude	Longitude
501	Thunder Bay-Windmill Pt., at east side of park by limestone ledges	42° 52' 08.52"	78° 59' 54.25"
502	Port Colborne, by canal entrance near boat launch	42° 54' 00.00"	79° 14' 00.00"
503	Port Burwell, inside west breakwall outside of main channel	42° 39' 00.00"	80° 49' 00.00"
504	Port Bruce-West Pier, across from bluff along limestone rubble	42° 40' 00.00"	81° 13' 00.00"
505	Port Stanley, westside of harbour, in front of large storage tanks	42° 03' 00.00"	82° 27' 00.00"
506	Wheatley, limestone rubble on west side of boat launch	42° 03' 00.00"	82° 36' 00.00"
507	Leamington, at municipal marina, by lighthouse, inside breakwall	42° 03' 00.00"	82° 34' 00.00"
508	Sturgeon Creek, south side of original harbour entrance	42° 01' 00.00"	82° 34' 00.00"
509	Kingsville, at mouth of Mill Creek at Lakeside Park	42° 02' 00.00"	82° 45' 00.00"
510	Colchester, along the inside of west breakwall of harbour mouth	42° 08' 00.00"	82° 55' 00.00"

Detroit River, 600 Series

Cladophora samples were collected from shoreline sites along the Detroit River on June 19 and 20, 1986 and June 9 and 10, 1987 for all three sites (Table 5). In 1988, samples were collected on June 8 and 15 for sites 602 and 603; however, there was no *Cladophora* at site 601, possibly due to large amounts of suspended sediments. The June 8 and 15 results for stations 602 and 603 were averaged for Figure Det.1.

Table 5: Detroit River Stations

Station	Location	Latitude	Longitude
601	Lake Erie Metro Park, at the mouth on the American shore	42° 00' 03.00"	83° 10' 02.00"
602	Riverside Marina, on the Canadian shore south of Bois Blanc Is.	42° 04' 00.00"	83° 05' 04.00"
603	Bridges Bay Park/Edgewater Marina, at the head of the river	42° 20' 00.00"	82° 55' 01.00"

St. Clair River, 700 Series

Cladophora samples were collected from a variety of shoreline sites along the St. Clair River (Table 6). On July 3, 1984 collections were made at sites 701-705. In 1986, *Cladophora* samples were collected on July 22-24 at sites 708, 710 and 712-716 and September 17-18 at sites 709-711, 713 and 715. In 1987, *Cladophora* samples were collected on July 21 at sites 708, 713 and 715. In 1988, samples were collected on July 19 at sites 708 and 713-715 and July 22 at site 709. Peak *Cladophora* biomass usually occurred in June for most study areas in the lower Great Lakes. However, the St. Clair River reached peak biomass in July due to the cooling effect of Lake Huron's low water temperatures. Thus, the 1986 results, which are graphed in Figure Scr.1, were reported for samples only collected in July.

Table 6: St. Clair River Stations

Station	Location	Latitude	Longitude
701	Corunna, 100m south of Talford Crk., opposite the Shell water tower	42° 53' 10.10"	82° 28' 01.30"
702	Corunna, at sewer south of large smoke stack	42° 53' 10.10"	82° 28' 01.30"
703	Corunna, cobble beach, 50m north of Pier 90	42° 53' 10.10"	82° 28' 01.30"
704	Corunna, at breakwall north of fast outfall	42° 53' 10.10"	82° 28' 01.30"
705	Corunna, by cobble beach at the foot of Beckwith St.	42° 53' 10.10"	82° 28' 01.30"
706	Sarnia Bluewater Bridge (control), 75m downstream of bridge	42° 59' 09.26"	82° 24' 37.89"
708	Point Edward, north side of Lambton Water Treatment Plant	43° 00' 15.00"	82° 25' 01.00"
709	Mueller, 150-200m south of Mueller Ltd.	42° 57' 20.00"	82° 25' 04.00"
710	Imperial Oil/C and Ferry, 30-50m south of discharge	42° 57' 40.00"	82° 24' 08.00"
711	Polysar, northside of breakwater at Polysar Pier, in front of lagoon	42° 56' 55.00"	82° 25' 08.00"
712	DOW, just south of two Dow stacks	42° 56' 12.00"	82° 26' 06.00"
713	Indian Reserve, 250-300m south of Suncor Dock	42° 55' 40.00"	82° 26' 55.00"
714	Algonac State Park, at breakwall at north end of park	42° 39' 10.00"	82° 30' 08.00"
715	Port Lambton, in front of Cottage Studio #88	42° 39' 05.00"	82° 30' 04.00"
716	Suncor Dock, by cement dock	42° 55' 55.00"	82° 26' 55.00"

Collingwood Harbour, 800 Series

Cladophora samples were collected from shoreline sites in Collingwood Harbour on June 18, 1986 at the 11 stations listed in Table 7.

Table 7: Collingwood Harbour Stations

Station	Location	Latitude	Longitude
801	Outside west breakwall, 70m from the mouth of harbour	44° 30' 00.00"	80° 10' 07.00"
802	Wooden marker, near TN21	44° 30' 00.00"	80° 10' 07.00"
803	Outside east breakwall, 450m from the mouth of harbour	44° 30' 00.00"	80° 10' 07.00"
804	Shipyard at north east corner of harbour	44° 30' 00.00"	80° 10' 07.00"
805	Small boat dock near TN26	44° 30' 00.00"	80° 10' 07.00"
806	Inside west breakwall, at south east corner of harbour	44° 30' 00.00"	80° 10' 07.00"
807	Landfill, at north point of harbour	44° 30' 00.00"	80° 10' 07.00"
808	South west shore of harbour	44° 30' 00.00"	80° 10' 07.00"
809	Urban Creek 1, 5-30m inside the mouth at the east side of harbour	44° 30' 00.00"	80° 10' 07.00"
810	Urban Creek 2, 5-15m inside the mouth at the east side of harbour	44° 30' 00.00"	80° 10' 07.00"
811	Landfill, at south point of harbour	44° 30' 00.00"	80° 10' 07.00"

Grand River, 900 Series

Cladophora samples were collected from shoreline sites along the Grand River, on June 11 and 16, 1986 at all stations except 902 which was collected on May 12, 1987 (Table 8). In 1986, samples were unattainable on June 11 at all the sites due to inclement weather, so the remaining stations were sampled on June 16th. Samples were taken at Station 901 (control) on both days. At Station 902, *Cladophora* was too sparse to sample on both days in 1986; however, in 1987 enough algae was found to obtain a sample. Data for the two samples obtained at station 901 was averaged, and only data from 1986 has been presented in Figure Grd.1.

Table 8: Grand River Stations

Station	Location	Latitude	Longitude
901	Bridgeport (control), mid-channel	43° 29' 00.00"	80° 28' 06.00"
902	Laurel Creek, ripple area upstream of bridge	43° 29' 09.00"	80° 28' 29.00"
903	STP outfall, 500m downstream of STP in mid-channel on east side of island	43° 28' 08.00"	80° 29' 00.00"
904	Urban Creek, within channel	43° 28' 03.00"	80° 28' 05.00"
905	Highway #7, mid channel, upstream of bridge	43° 28' 08.00"	80° 25' 04.00"
906	Above New Breslube Creek, mid-stream in rapids	43° 27' 06.00"	80° 25' 01.00"
907	New Breslube Creek, upstream of road culvert at new metal culvert	43° 27' 08.00"	80° 24' 05.00"
908	Highway #8, upstream of highway, downstream of old bridges on south side of river	43° 25' 02.00"	80° 25' 00.00"

RESULTS

I. Canagagigue Creek, 001 Series:

Elemental concentrations in *Cladophora* collected from Canagagigue Creek at stations 001-006, for the year 1987.

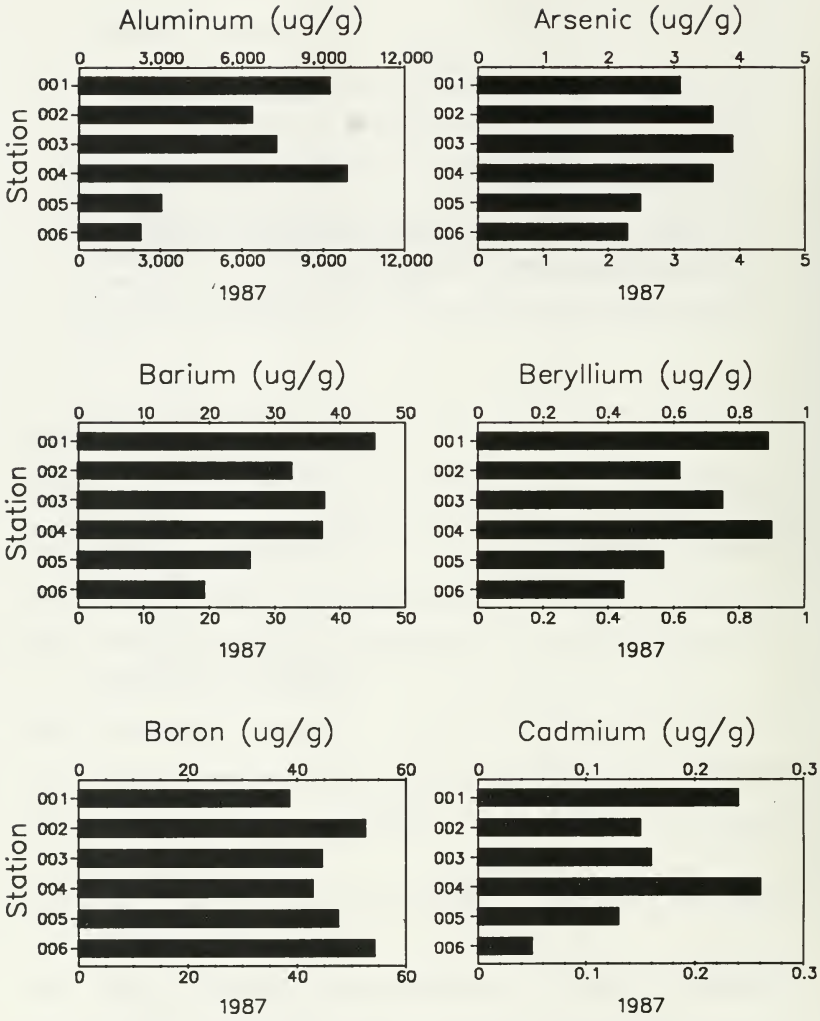


Figure Can. 1: Elemental concentrations in Cladophora collected from Canagagigue Creek.

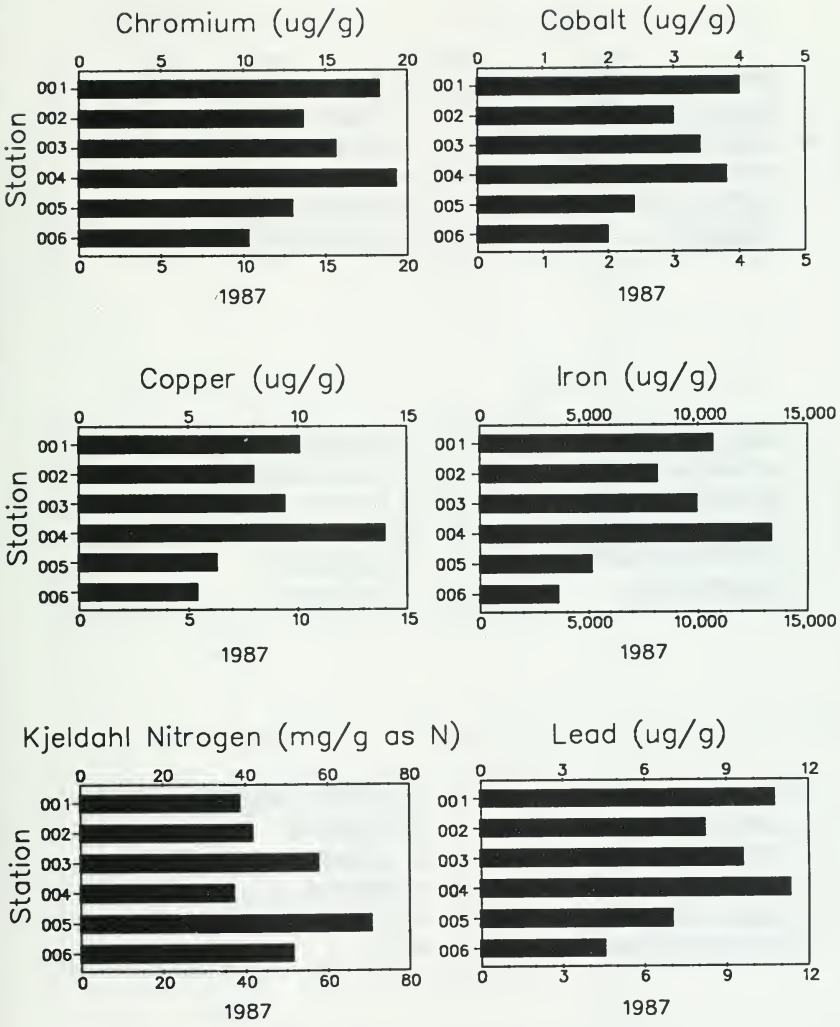


Figure Can.2: Elemental concentrations in Cladophora collected from Canagagigue Creek.

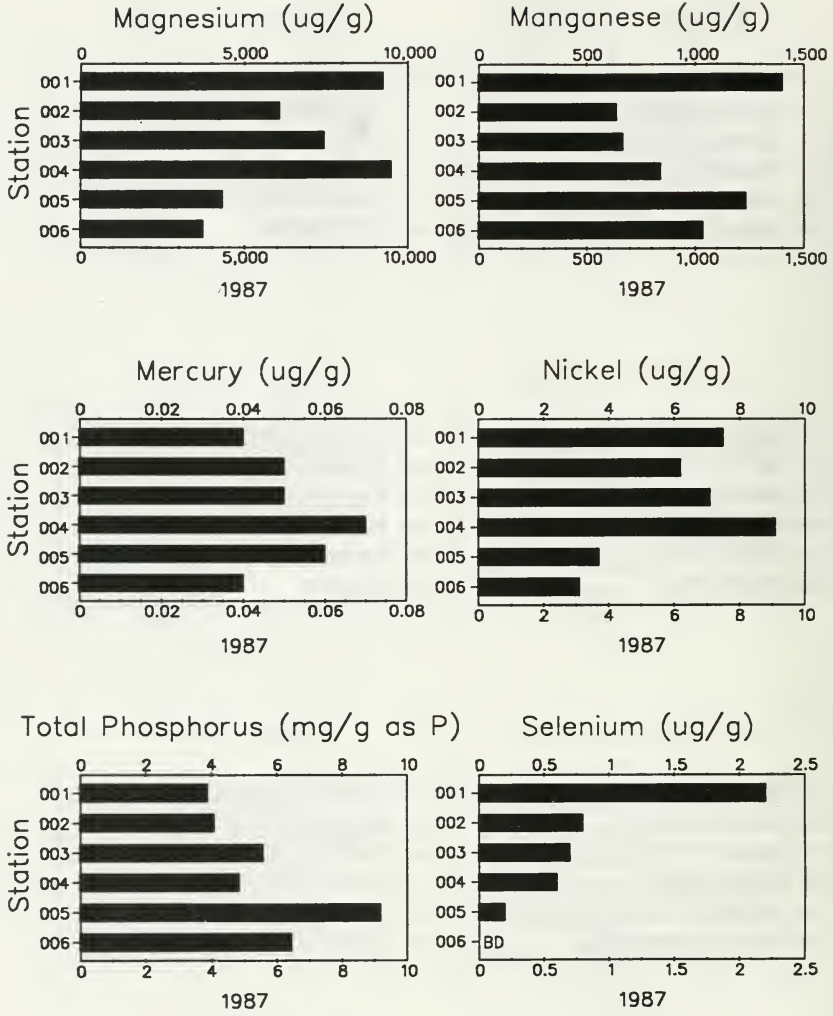


Figure Can.3: Elemental concentrations in Cladophora collected from Canagagigue Creek.

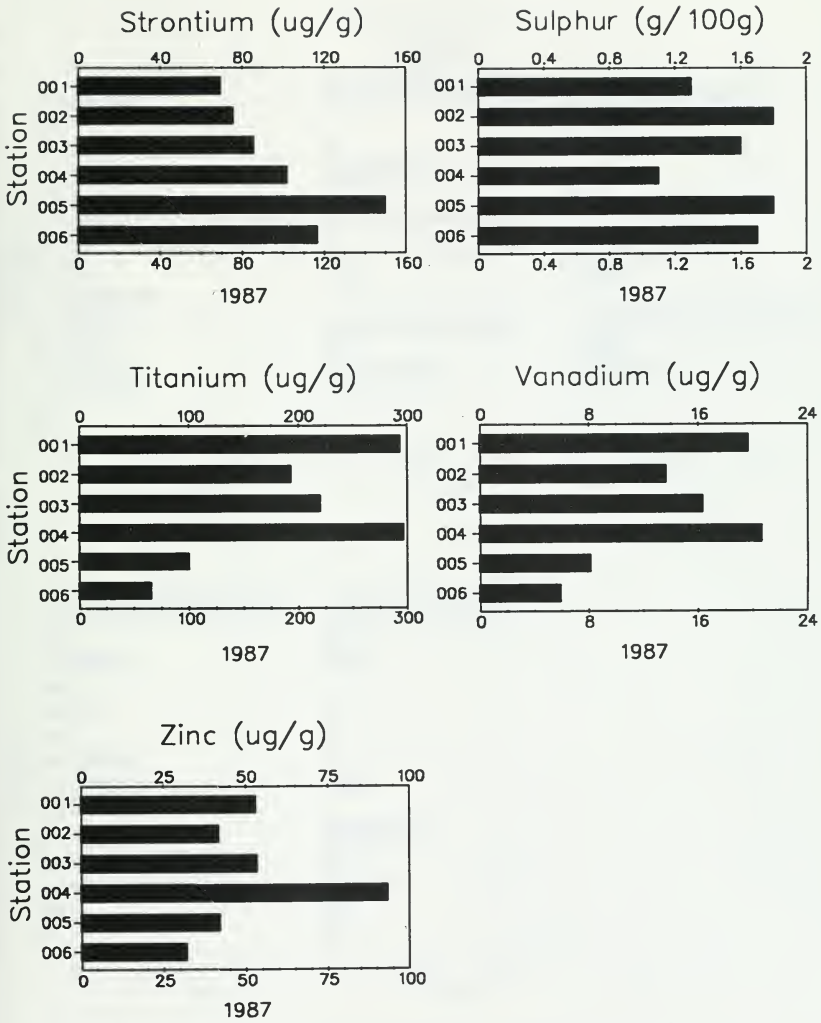


Figure Can.4: Elemental concentrations in Cladophora collected from Canagagigue Creek.

II. Lake Ontario, 300 Series:

Elemental concentrations in *Cladophora* collected from Lake Ontario at stations 304, 306, 317-326, 350, 374 and 391, for the years 1981-1984.

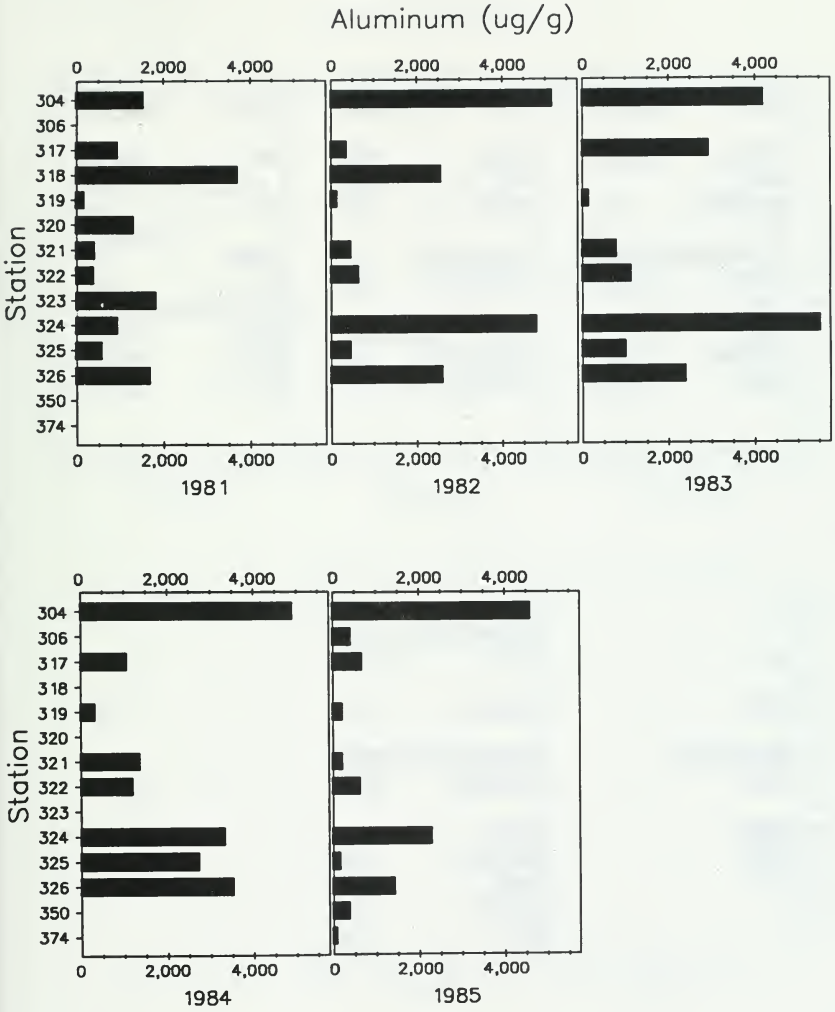


Figure Ont. 1: Elemental concentrations in Cladophora collected from Lake Ontario.

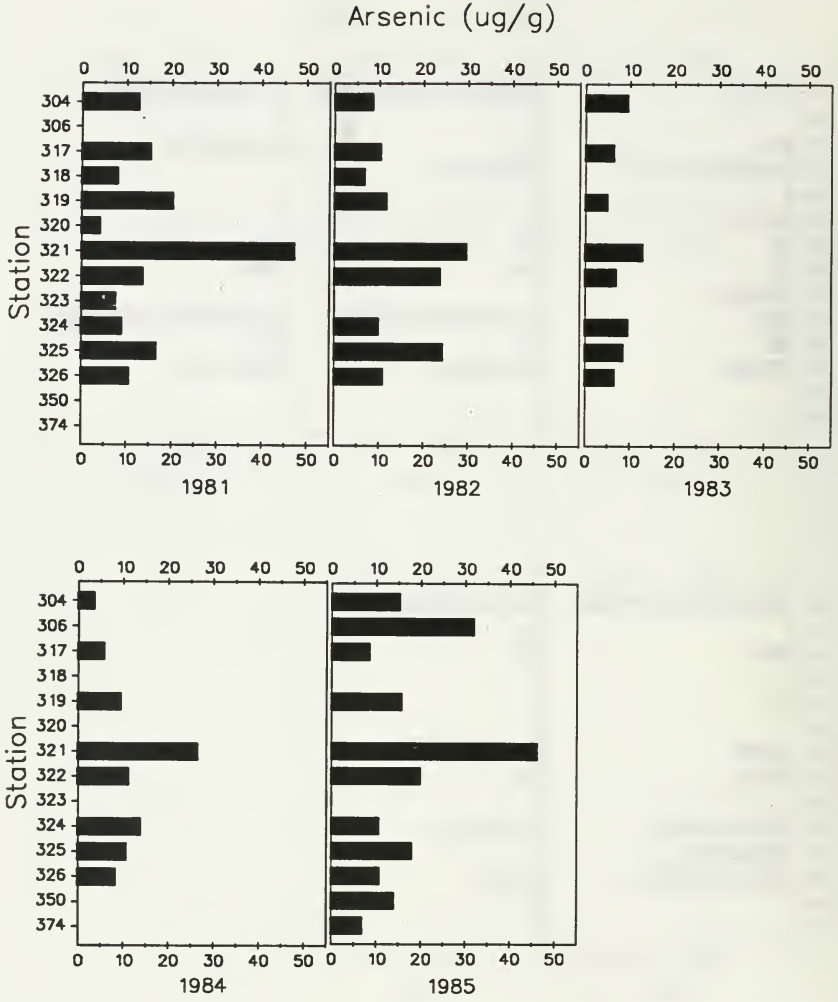


Figure Ont.2: Elemental concentrations in Cladophora collected from Lake Ontario.

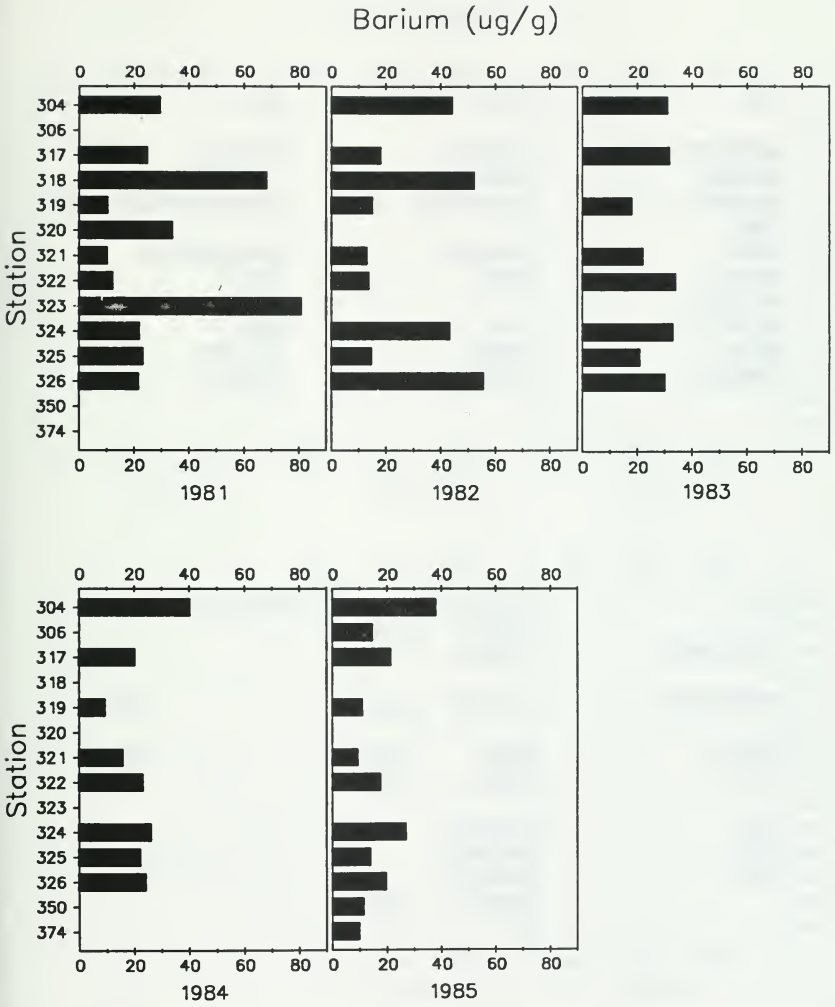


Figure Ont.3: Elemental concentrations in Cladophora collected from Lake Ontario.

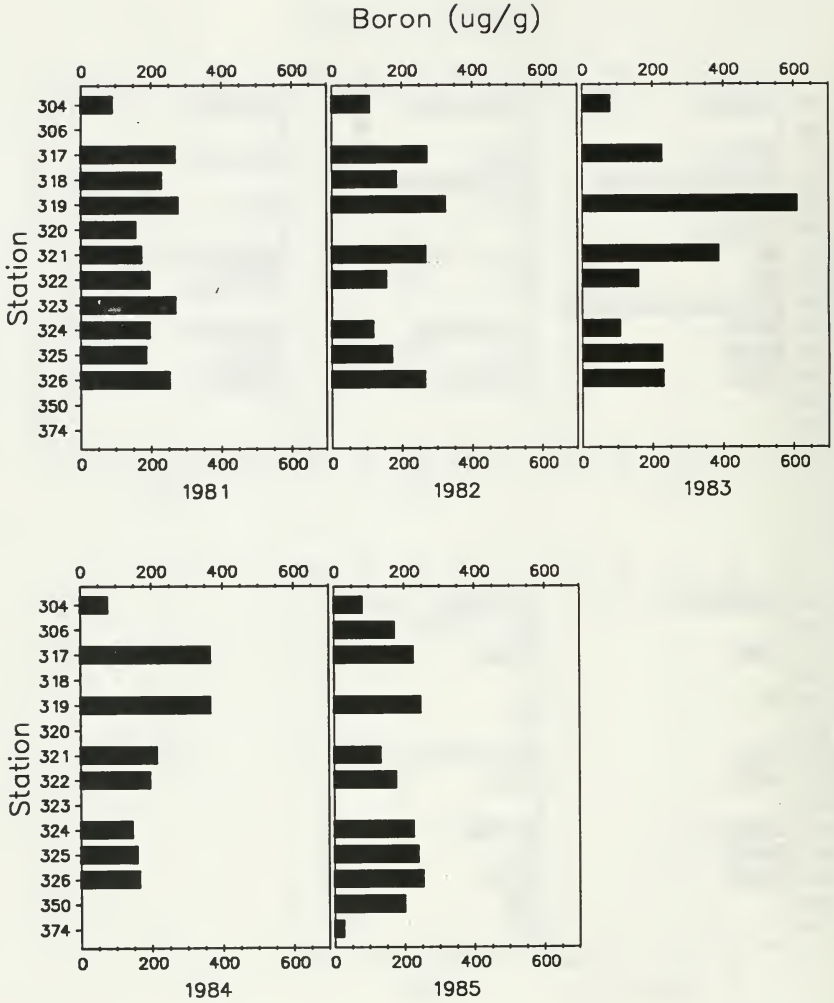


Figure Ont.4: Elemental concentrations in Cladophora collected from Lake Ontario.

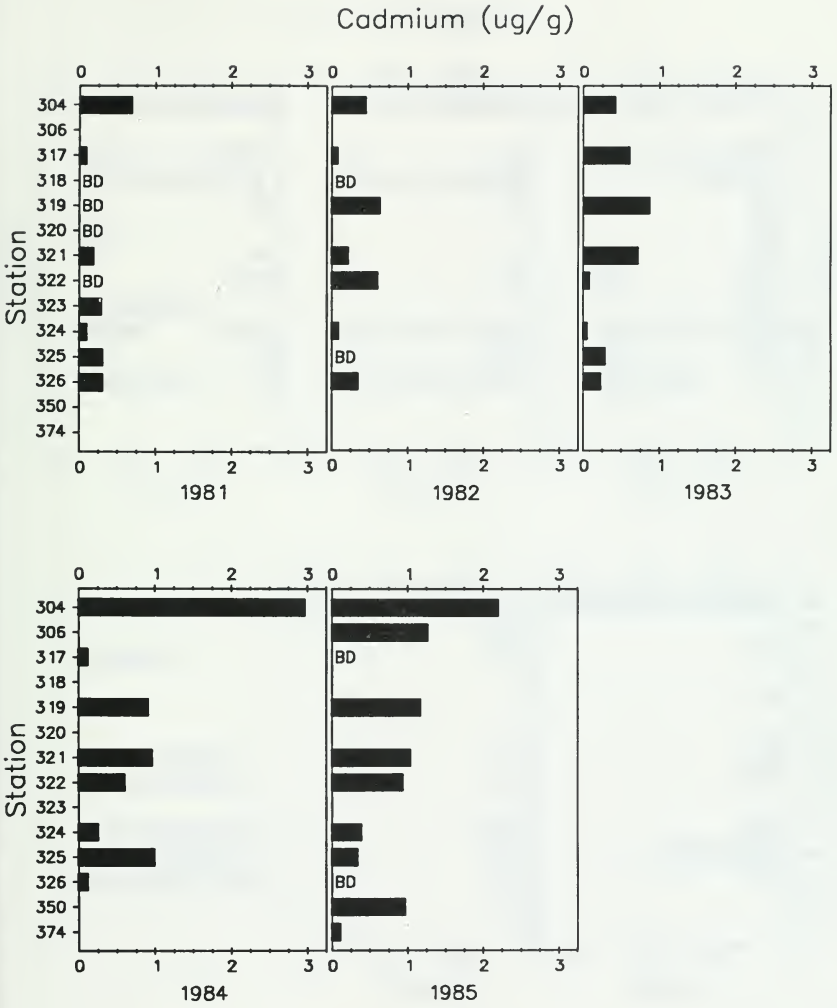


Figure Ont.5: Elemental concentrations in Cladophora collected from Lake Ontario.

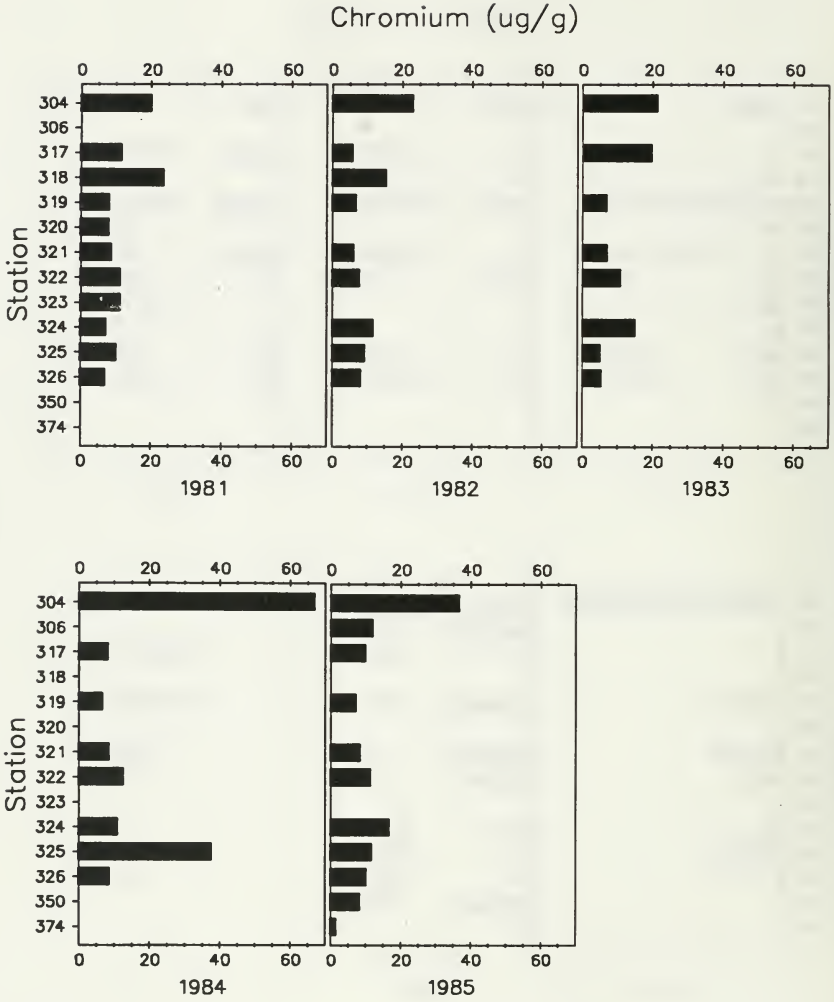


Figure Ont.6: Elemental concentrations in Cladophora collected from Lake Ontario.

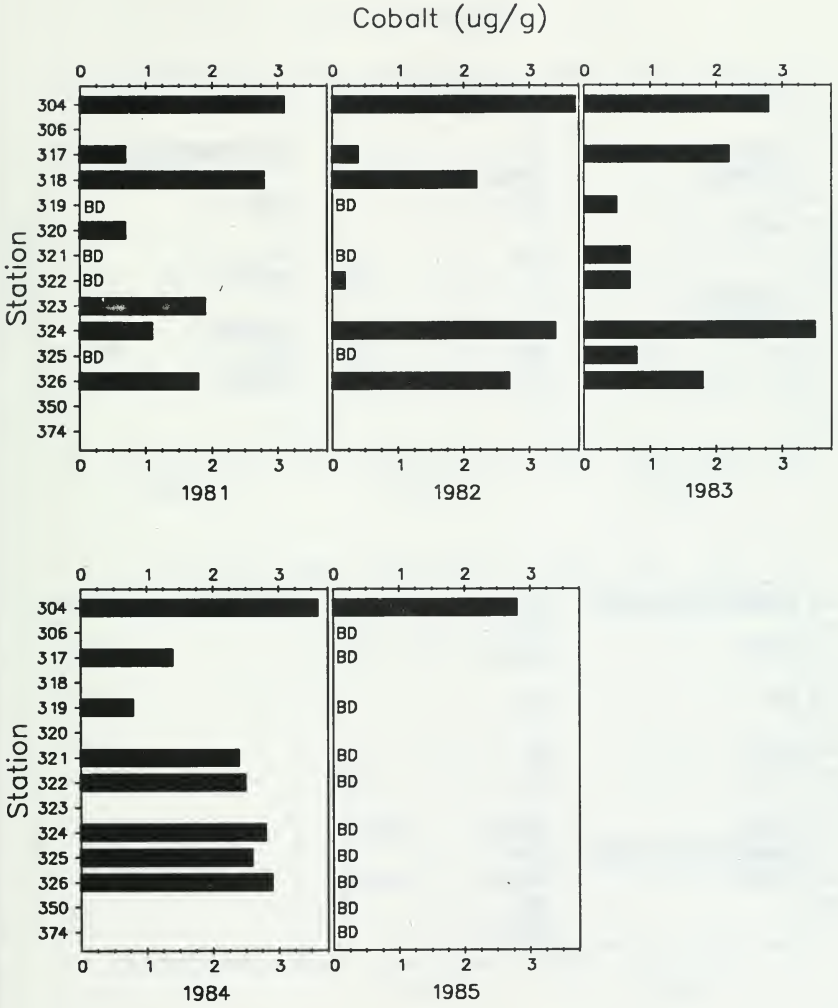


Figure Ont.7: Elemental concentrations in Cladophora collected from Lake Ontario.

Figure Ont.8: Elemental concentrations in Cladophora collected from Lake Ontario.

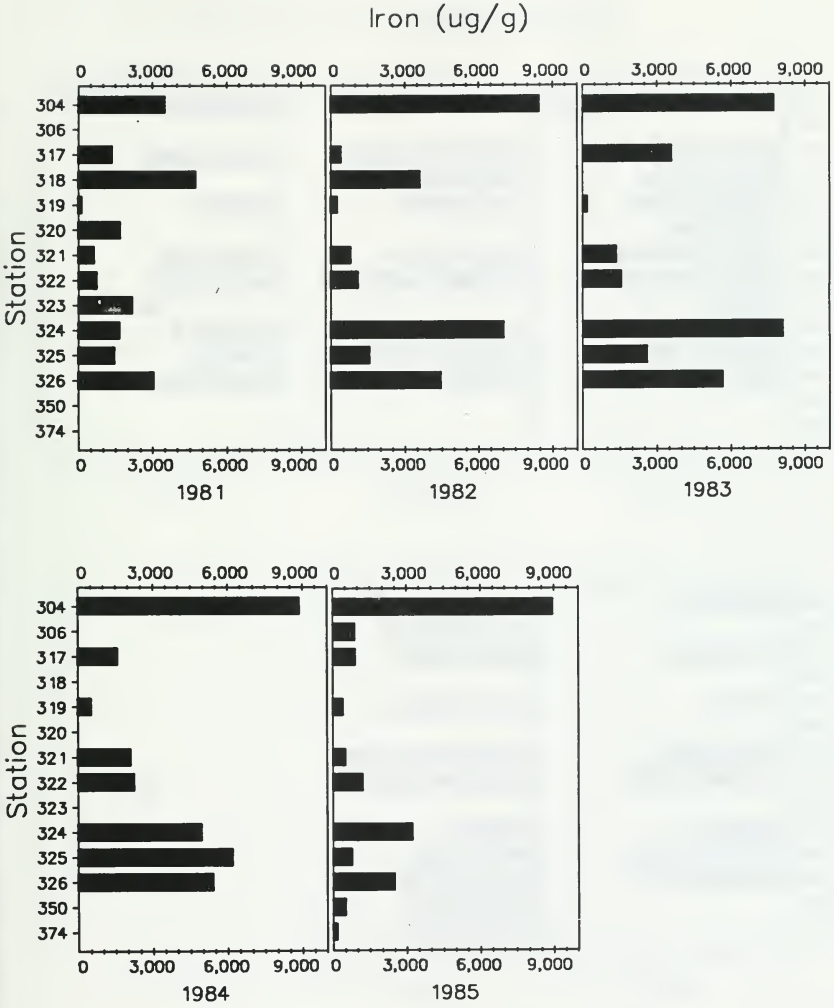


Figure Ont.9: Elemental concentrations in Cladophora collected from Lake Ontario.

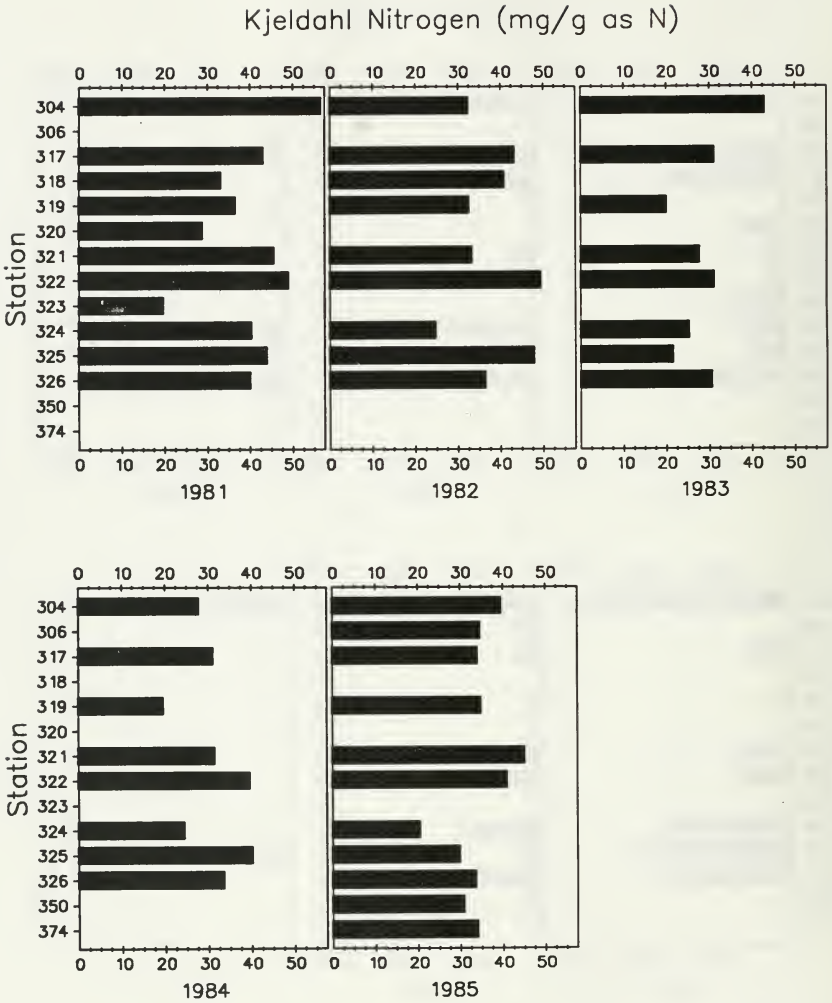


Figure Ont. 10: Elemental concentrations in Cladophora collected from Lake Ontario.

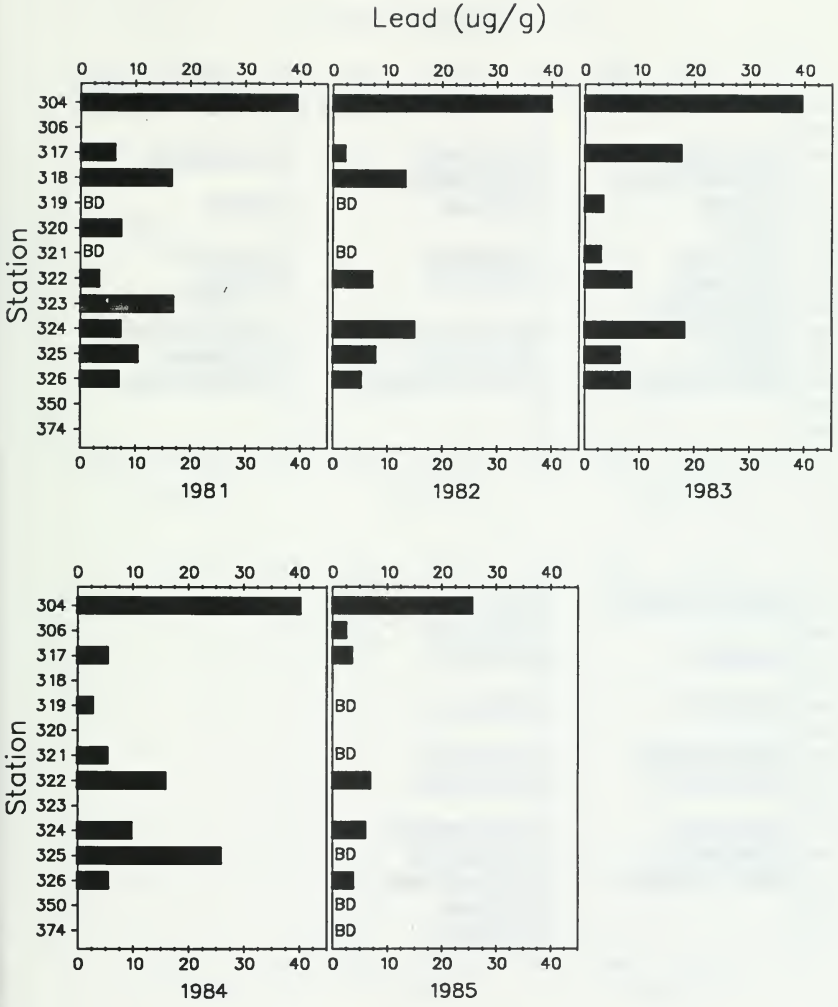


Figure Ont.11: Elemental concentrations in Cladophora collected from Lake Ontario.

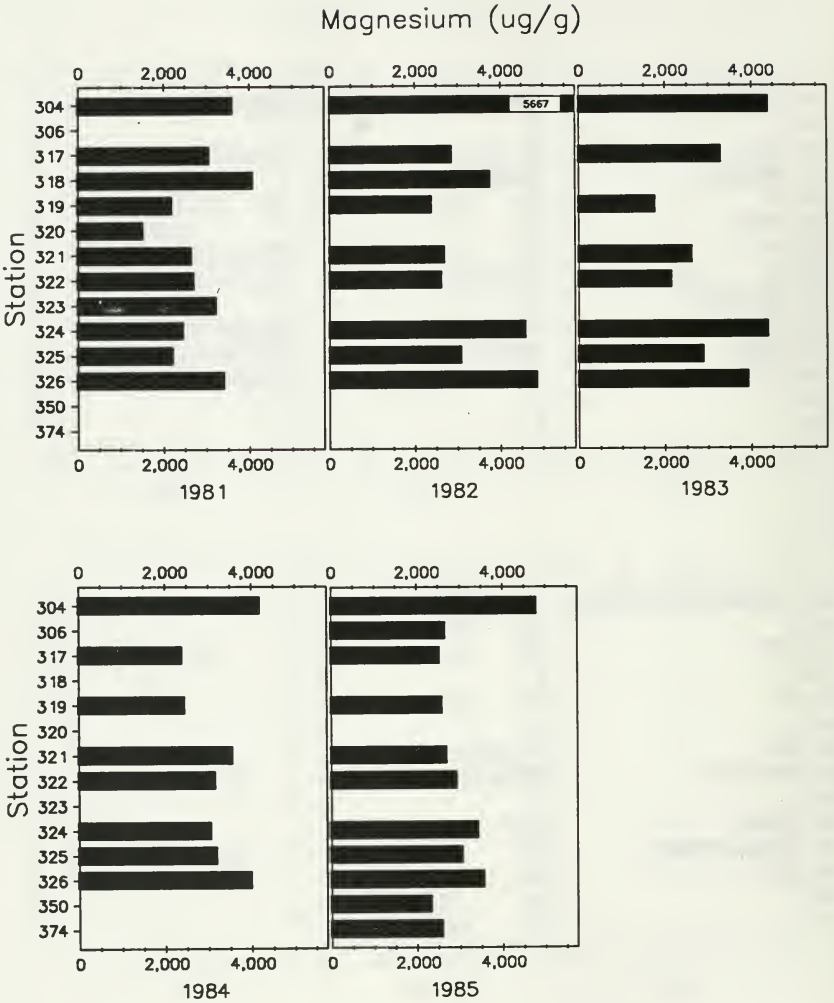


Figure Ont. 12: Elemental concentrations in Cladophora collected from Lake Ontario.

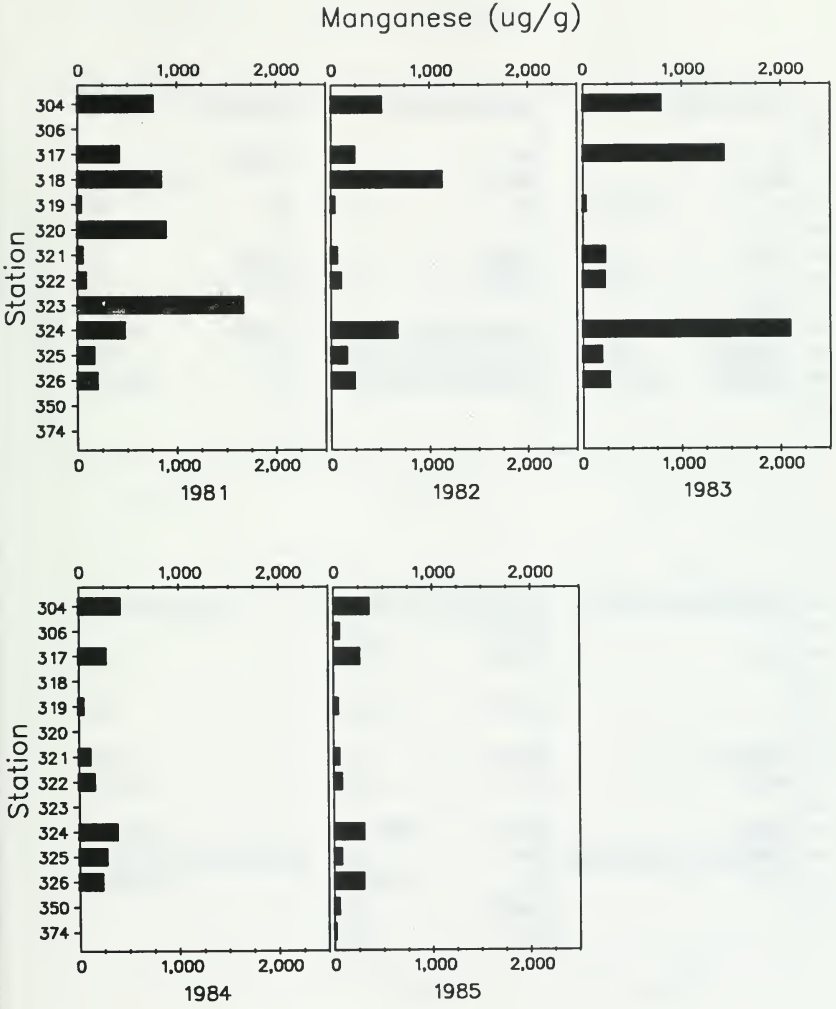


Figure Ont. 13: Elemental concentrations in Cladophora collected from Lake Ontario.

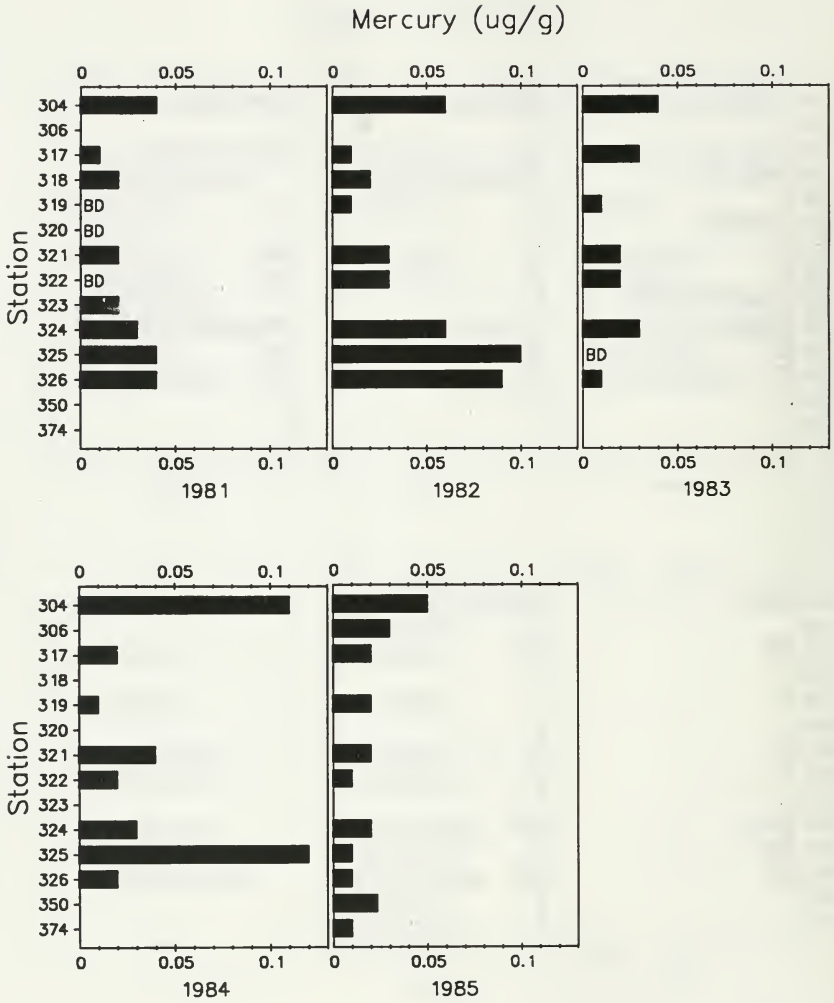


Figure Ont. 14: Elemental concentrations in Cladophora collected from Lake Ontario.

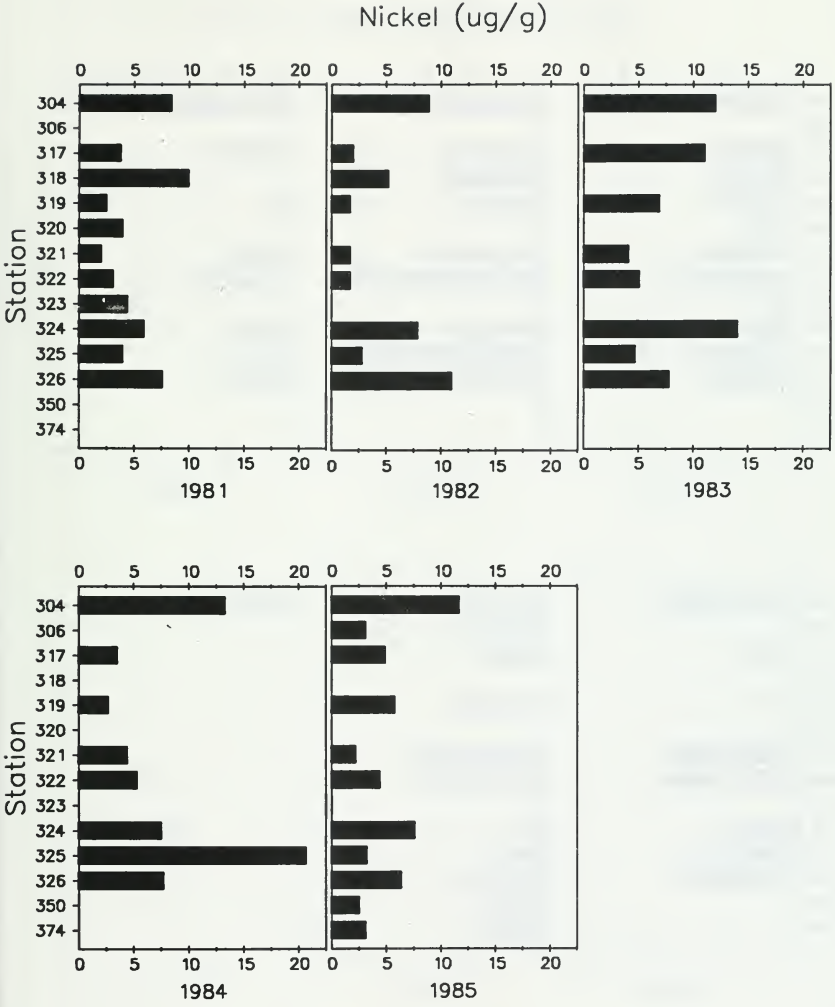


Figure Ont. 15: Elemental concentrations in Cladophora collected from Lake Ontario.

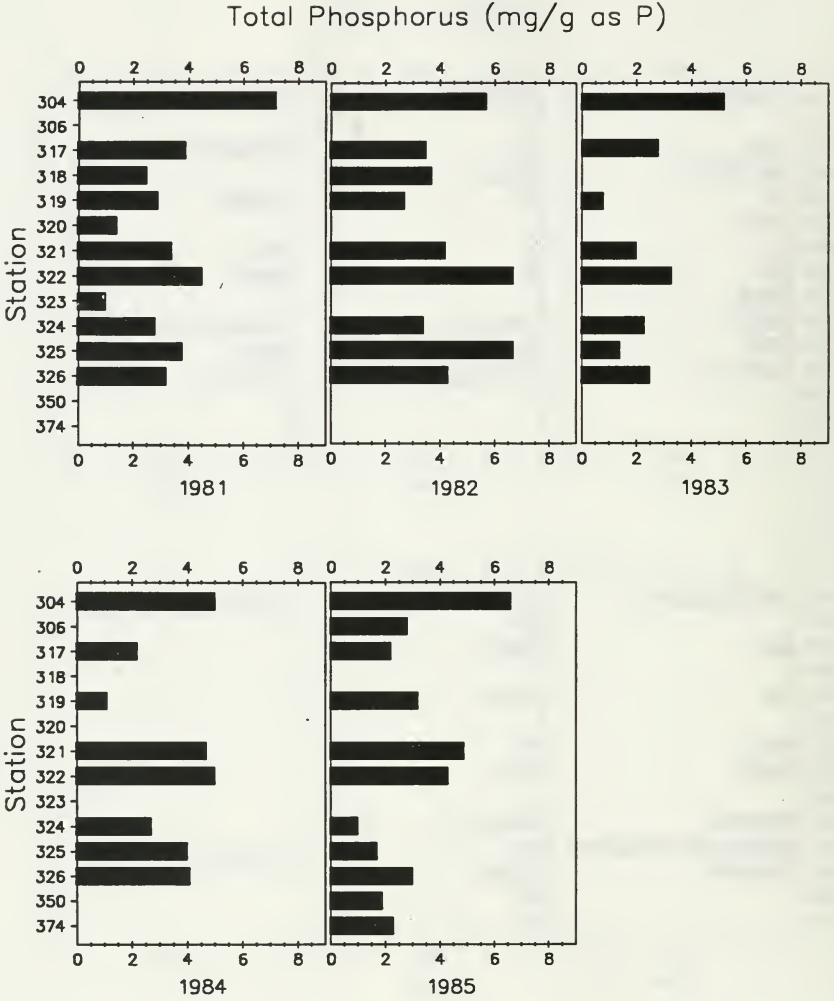


Figure Ont. 16: Elemental concentrations in Cladophora collected from Lake Ontario.

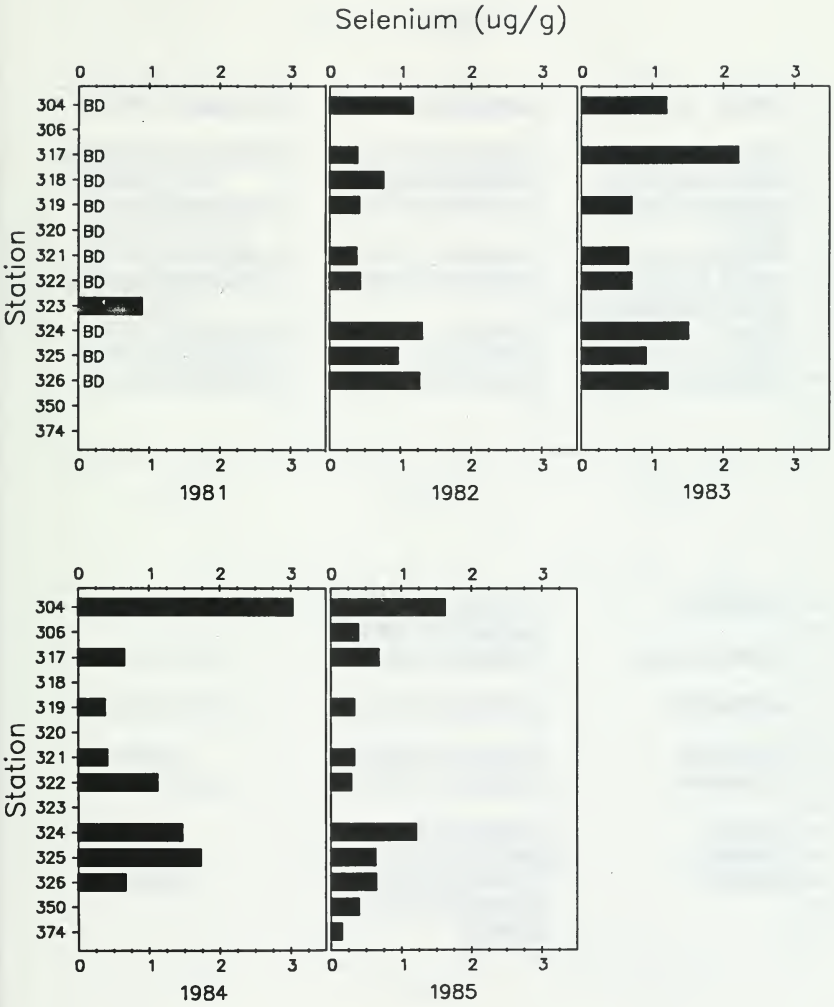


Figure Ont. 17: Elemental concentrations in Cladophora collected from Lake Ontario.

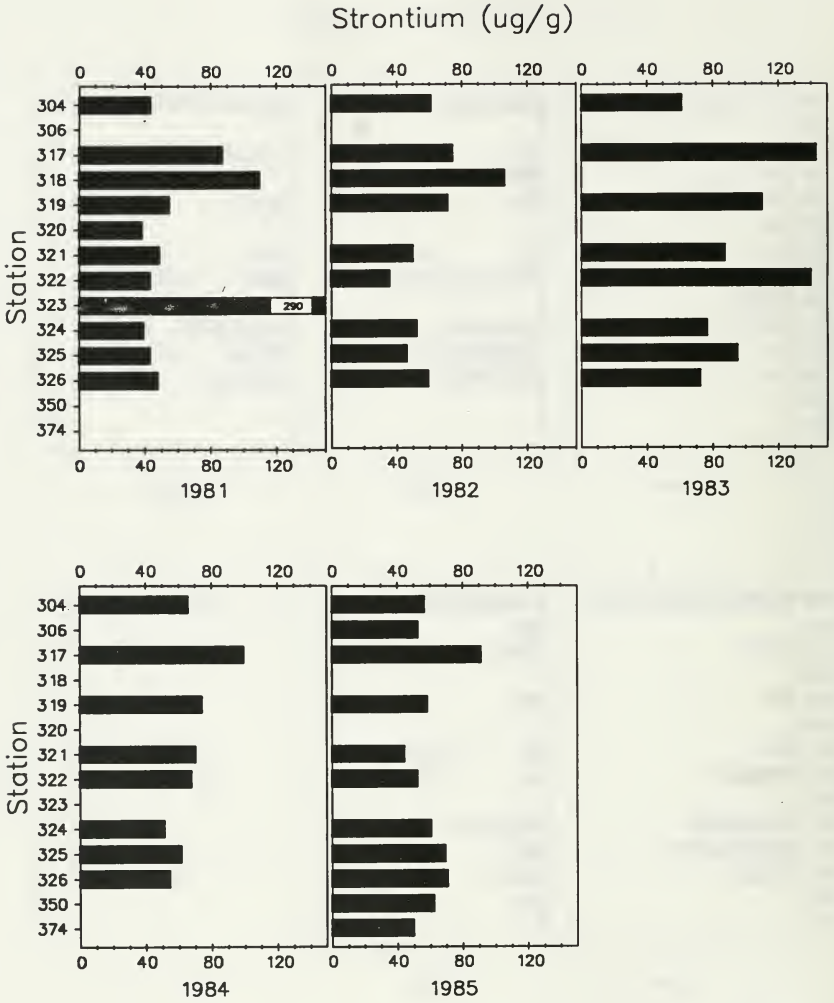


Figure Ont. 18: Elemental concentrations in Cladophora collected from Lake Ontario.

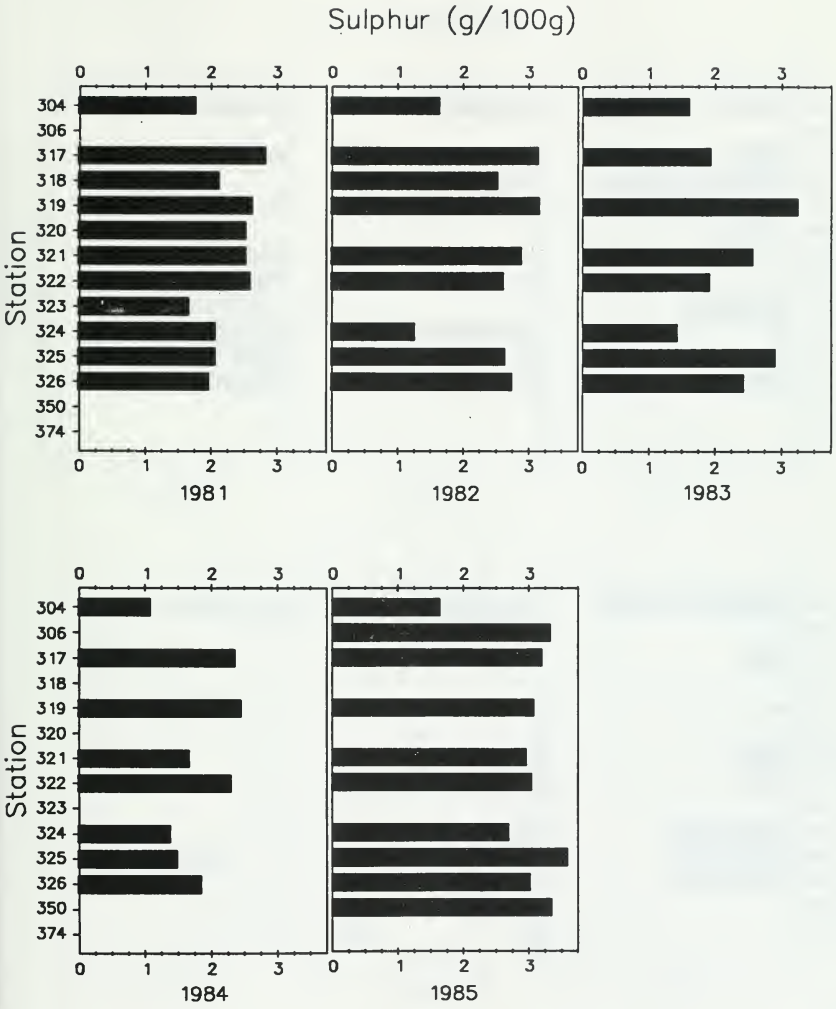


Figure Ont. 19: Elemental concentrations in Cladophora collected from Lake Ontario.

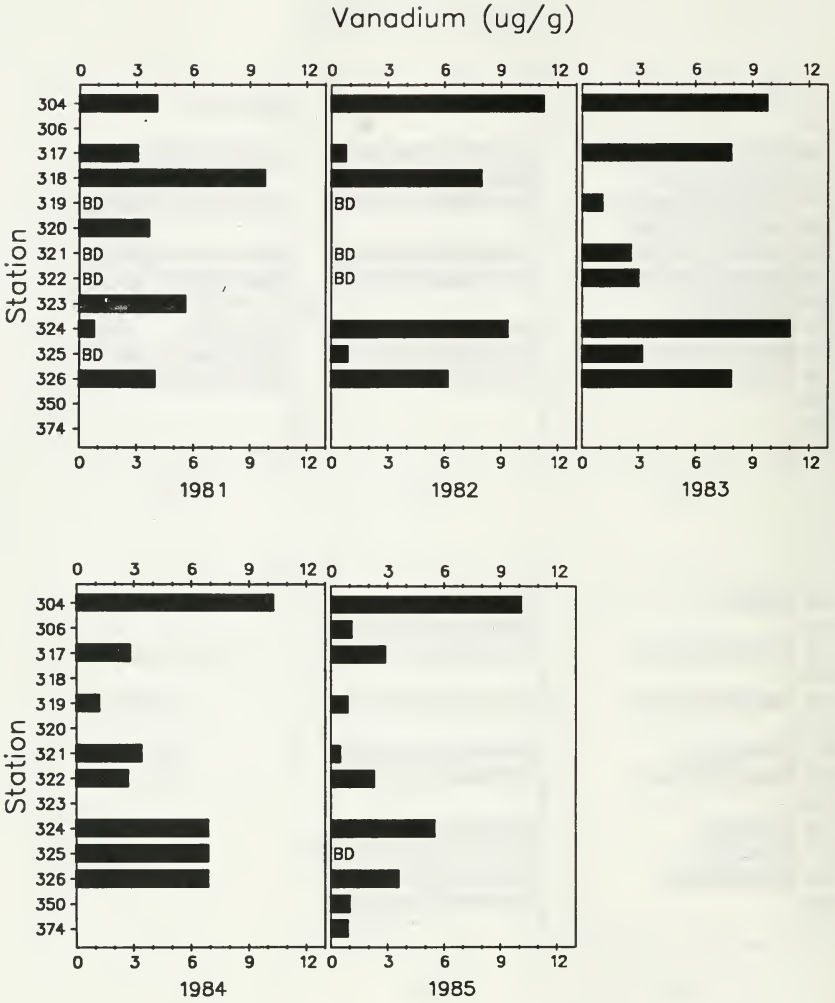


Figure Ont.20: Elemental concentrations in Cladophora collected from Lake Ontario.

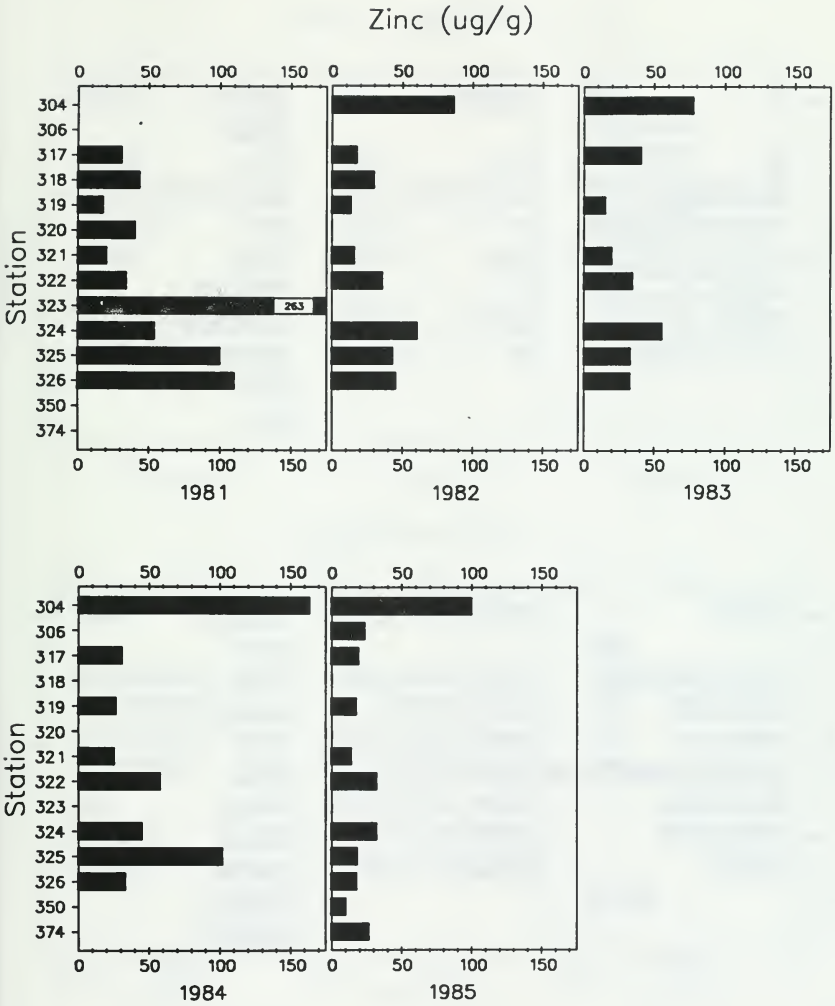


Figure Ont.21: Elemental concentrations in Cladophora collected from Lake Ontario.

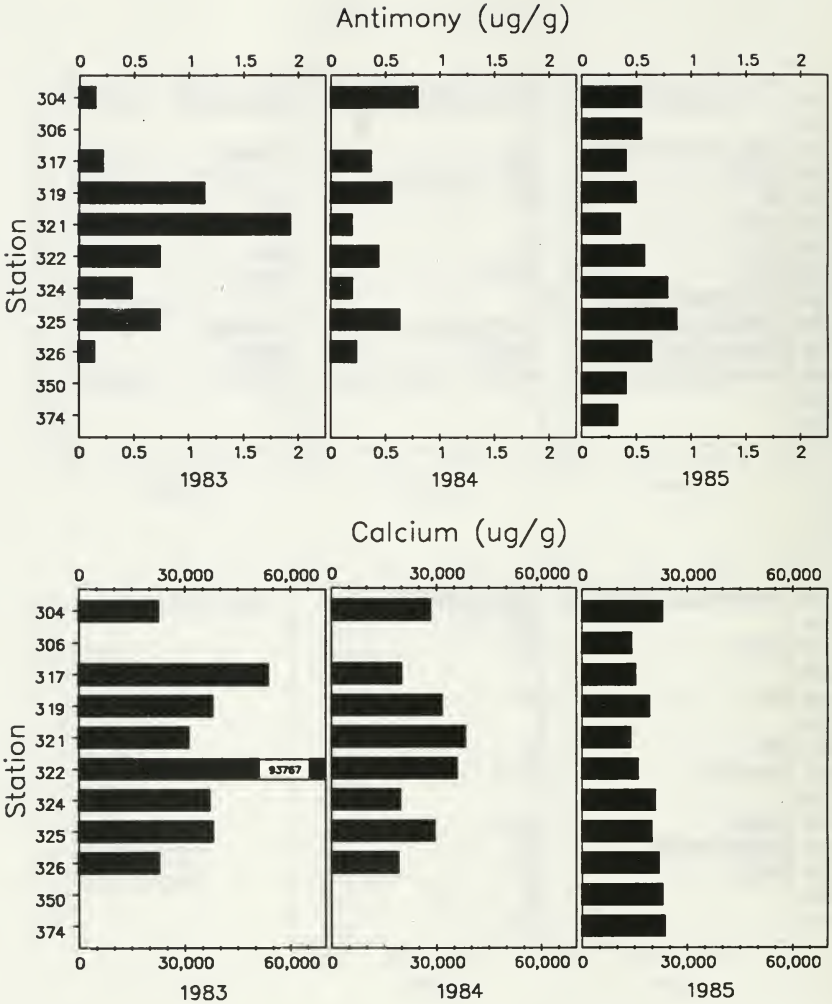


Figure Ont.22: Elemental concentrations in Cladophora collected from Lake Ontario.

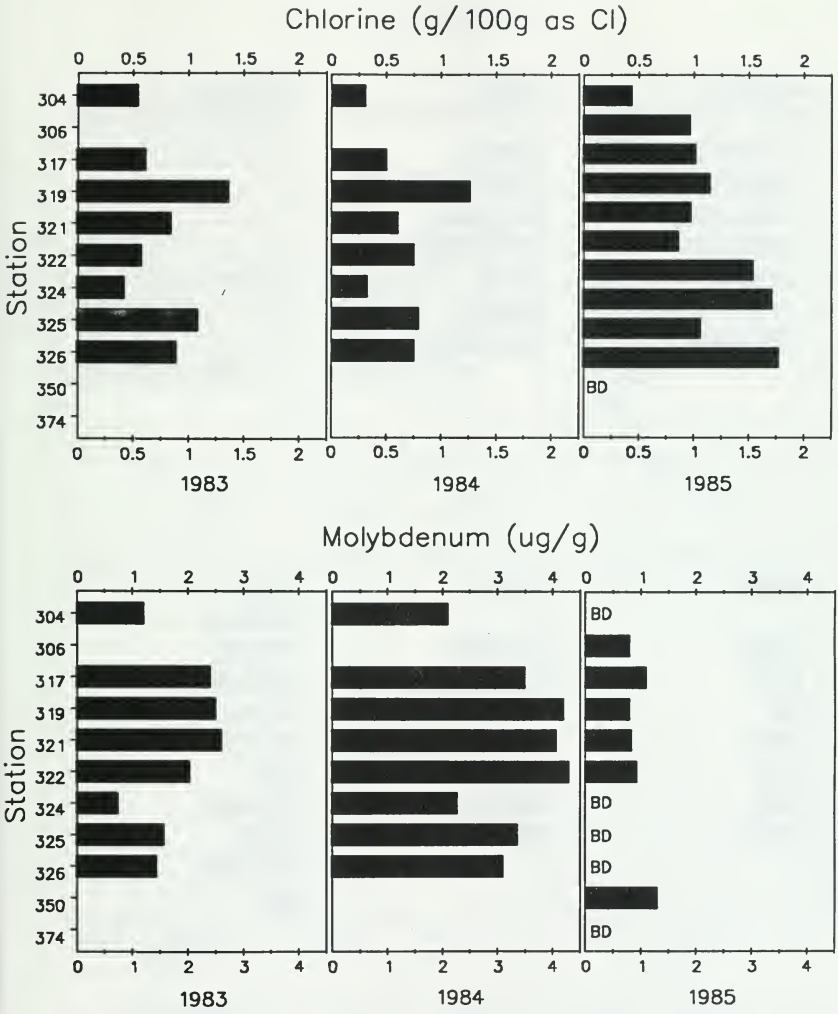


Figure Ont.23: Elemental concentrations in Cladophora collected from Lake Ontario.

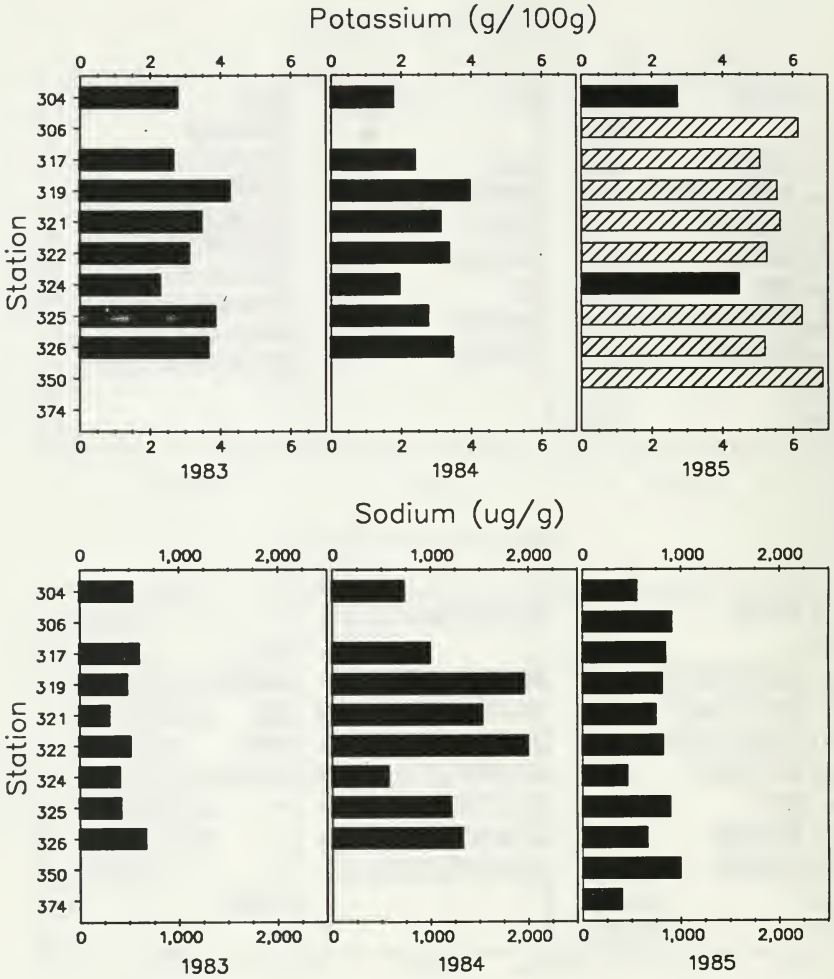


Figure Ont.24: Elemental concentrations in Cladophora collected from Lake Ontario.
▨ Actual concentration of potassium was possibly greater than the value indicated.

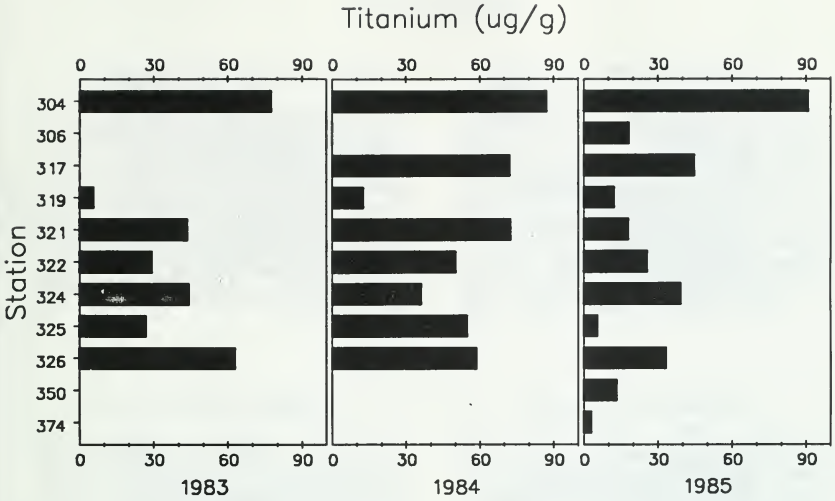


Figure Ont.25: Elemental concentrations in Cladophora collected from Lake Ontario.

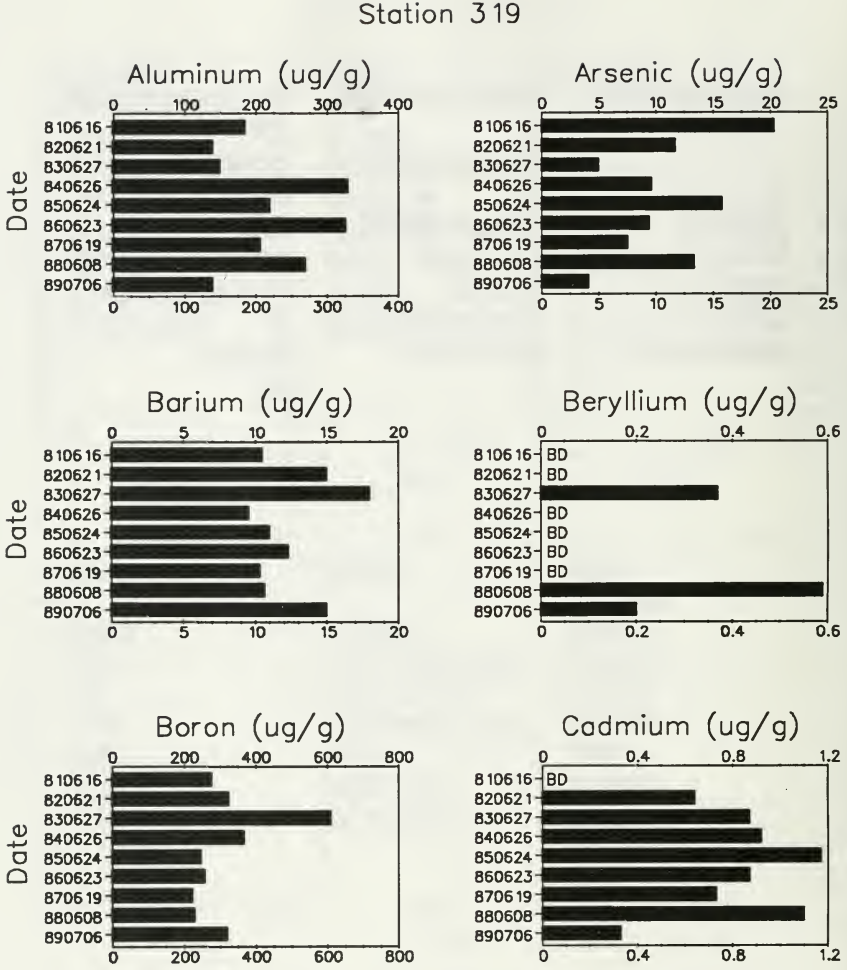


Figure Ont.26: Elemental concentrations in Cladophora collected from Lake Ontario.

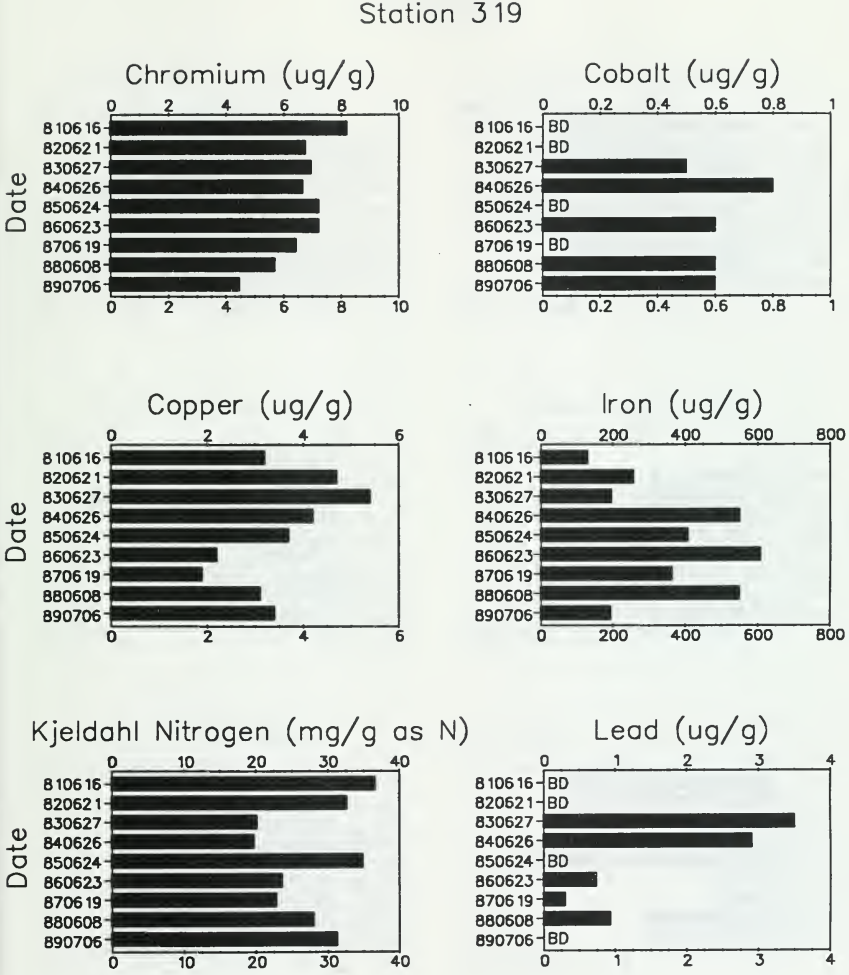


Figure Ont.27: Elemental concentrations in Cladophora collected from Lake Ontario.

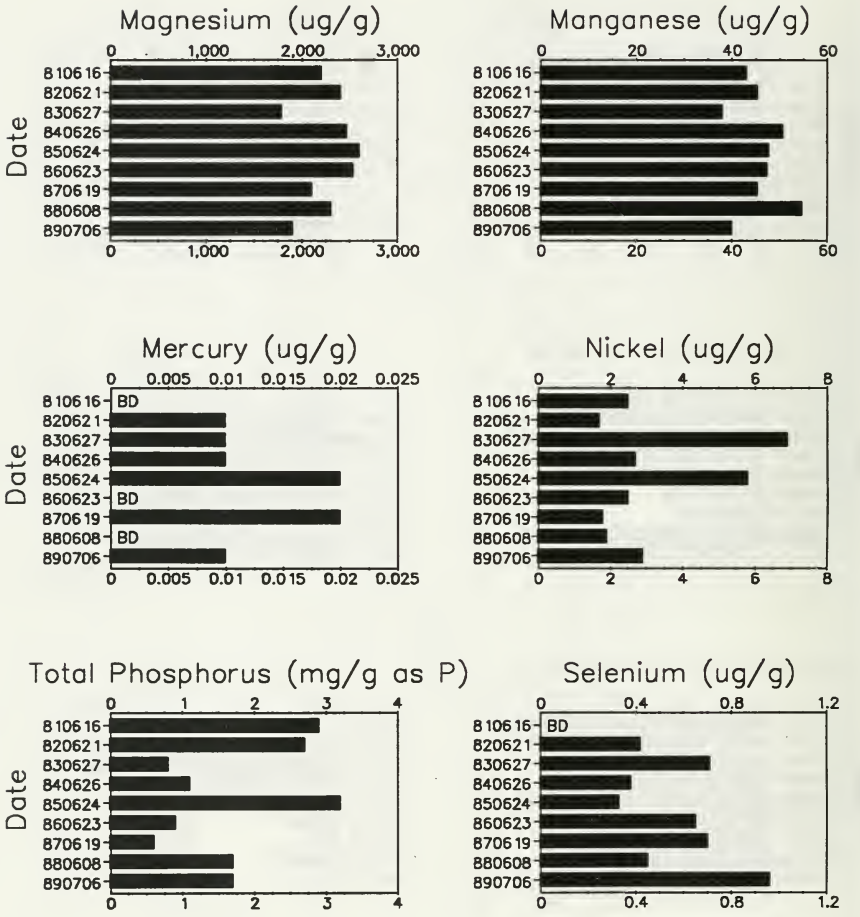


Figure Ont.28: Elemental concentrations in Cladophora collected from Lake Ontario.

Station 319

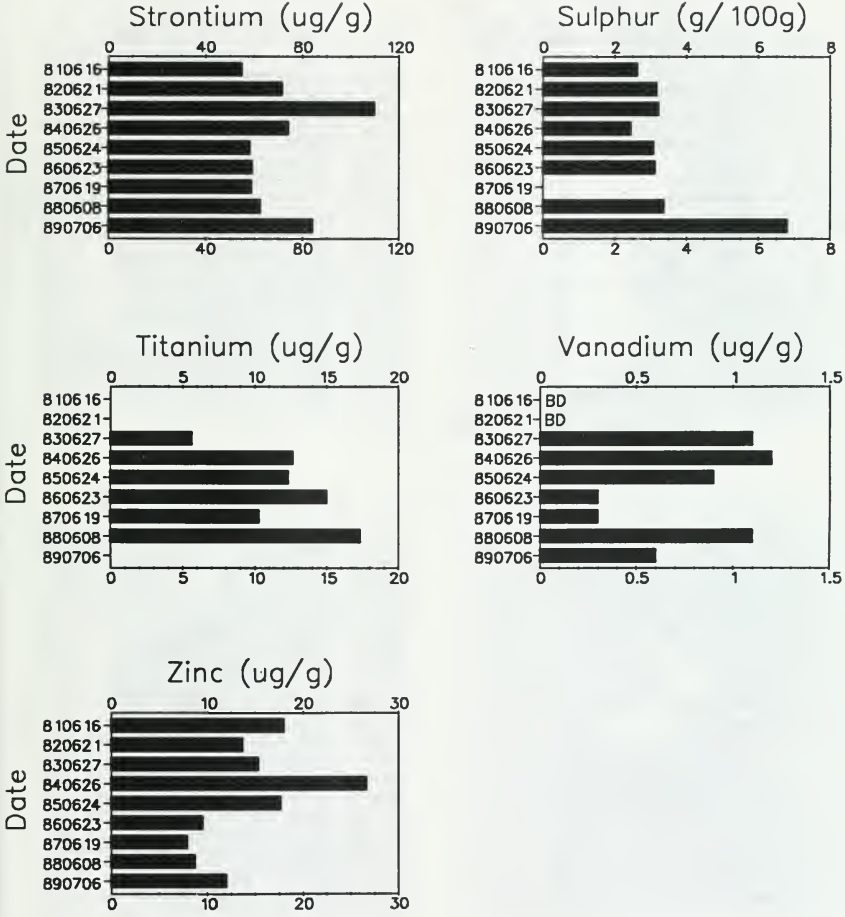


Figure Ont.29: Elemental concentrations in Cladophora collected from Lake Ontario.

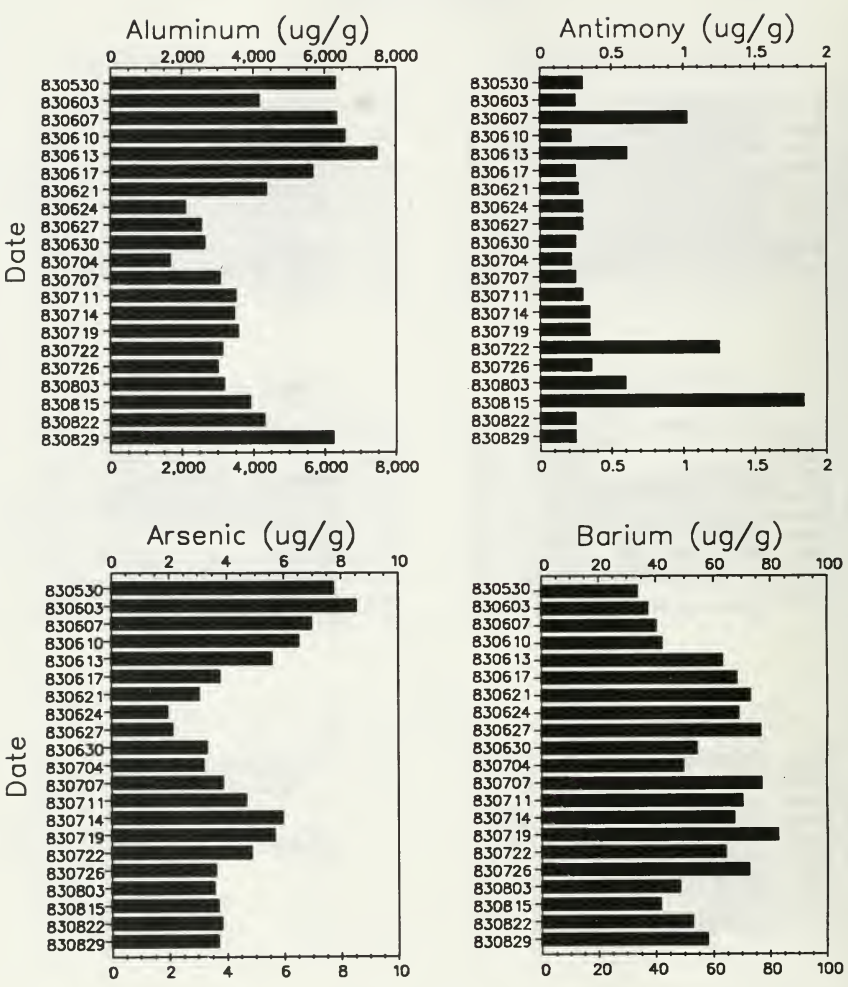


Figure Ont.30: Elemental concentrations in Cladophora collected from Lake Ontario.

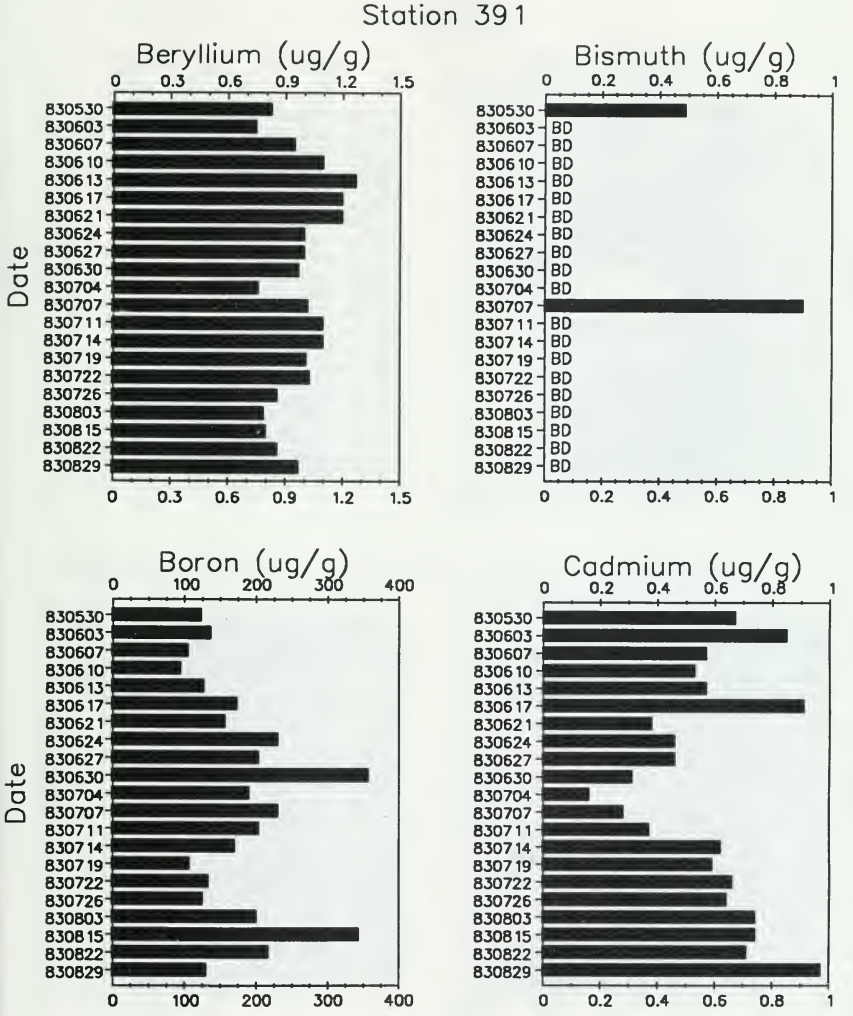


Figure Ont.31: Elemental concentrations in Cladophora collected from Lake Ontario.

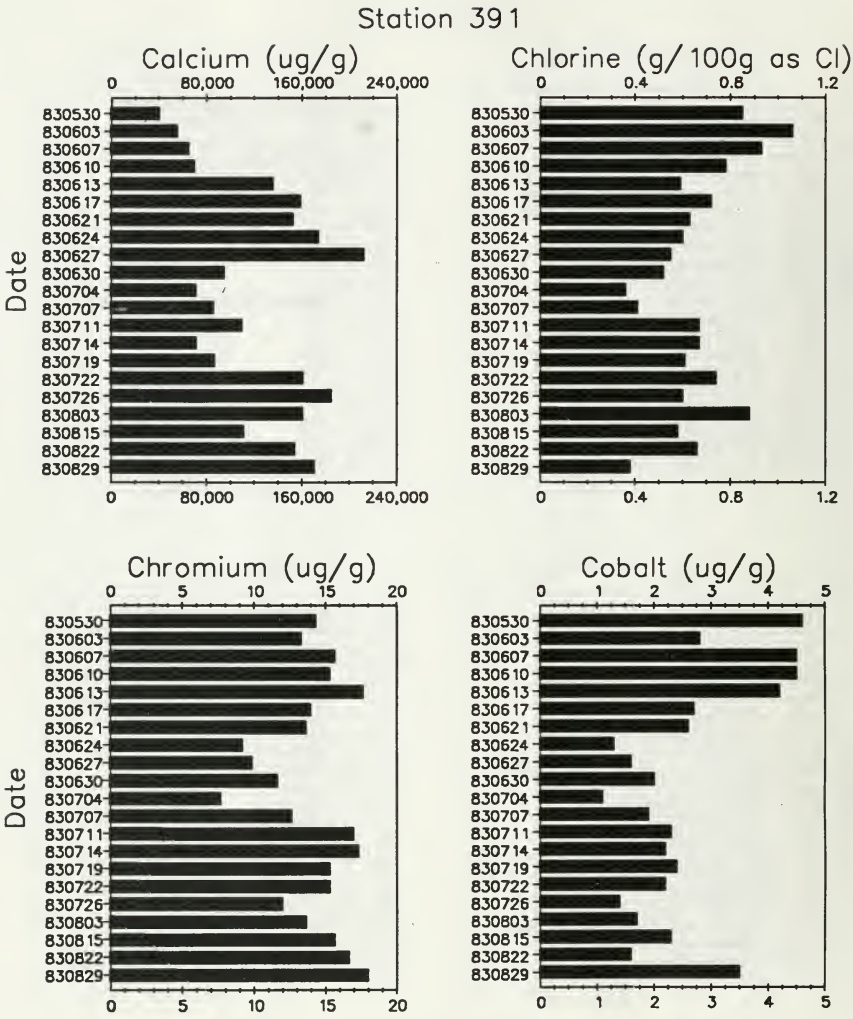


Figure Ont.32: Elemental concentrations in Cladophora collected from Lake Ontario.

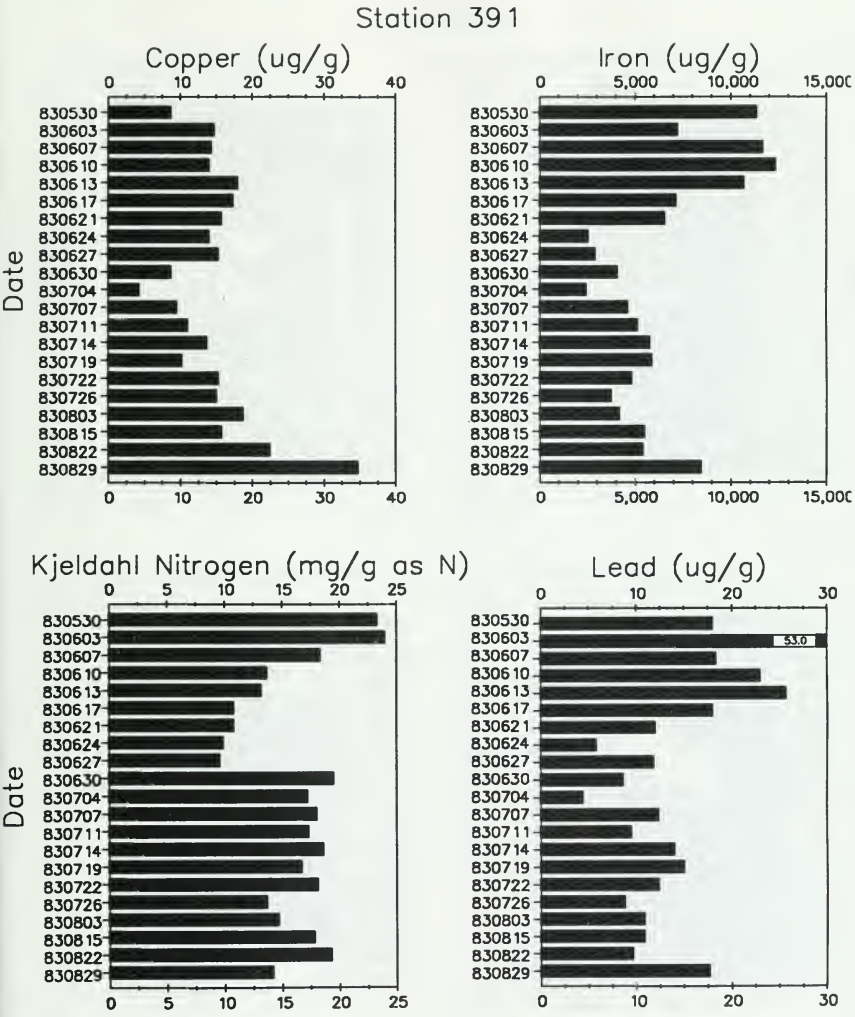


Figure Ont.33: Elemental concentrations in Cladophora collected from Lake Ontario.

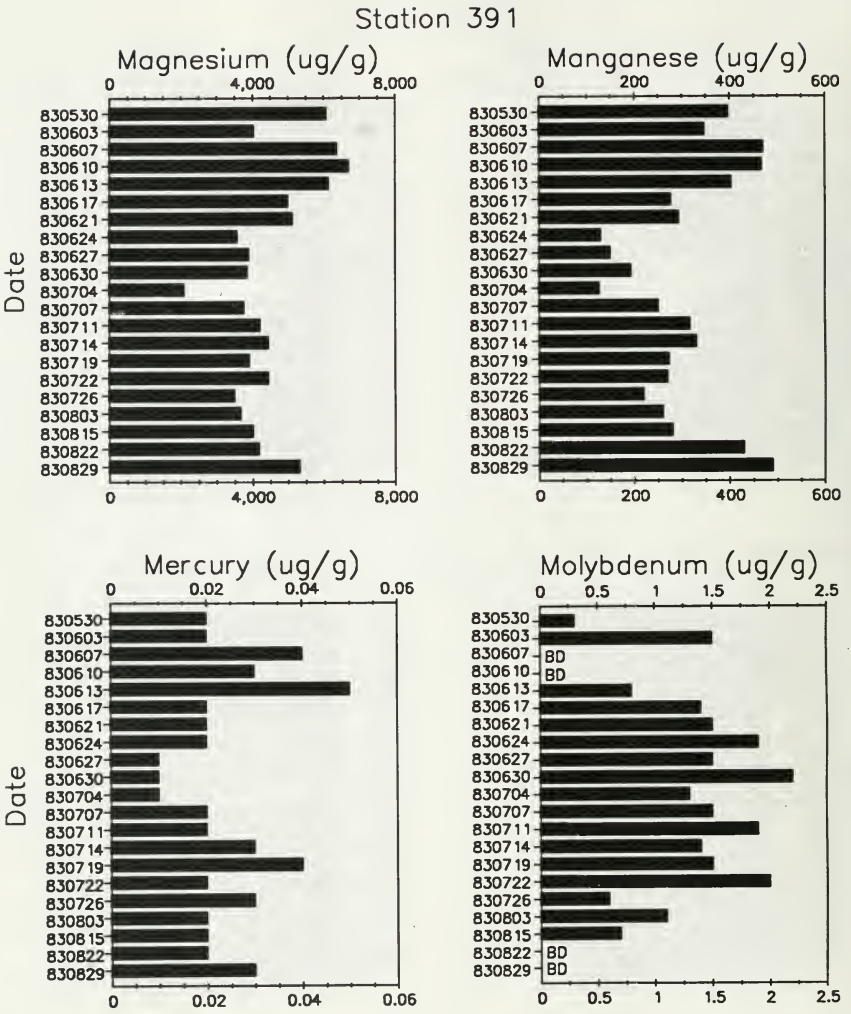


Figure Ont.34: Elemental concentrations in Cladophora collected from Lake Ontario.

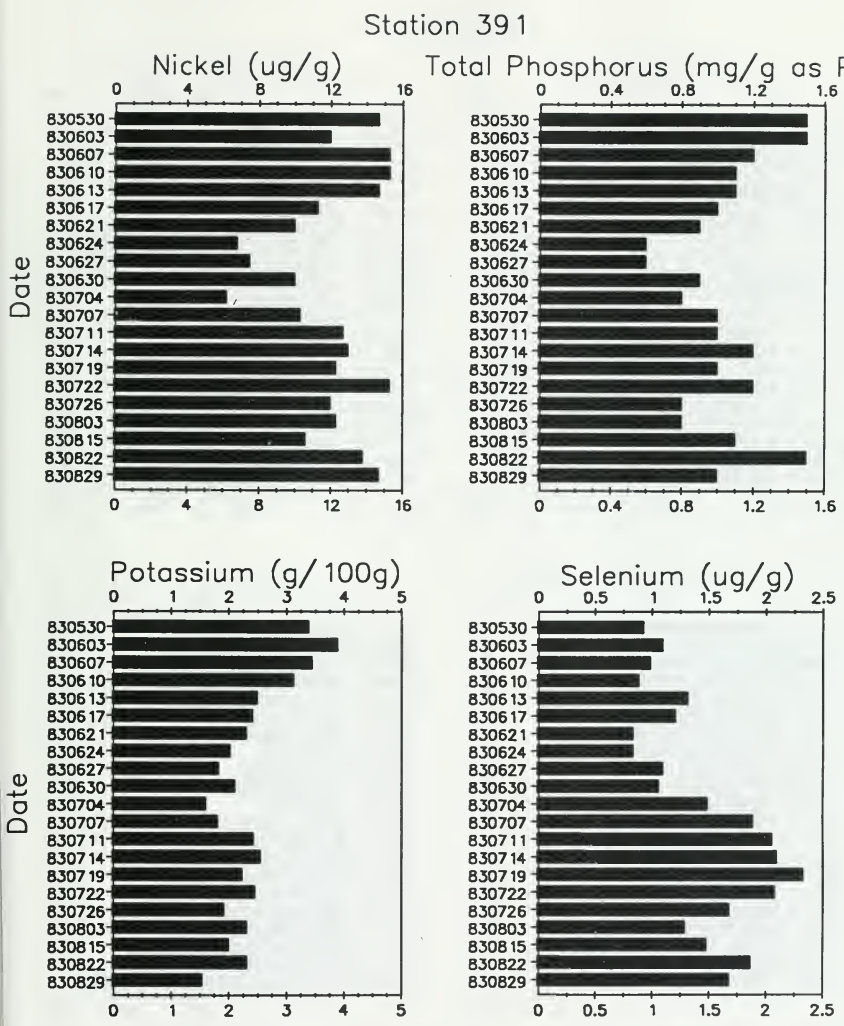


Figure Ont.35: Elemental concentrations in Cladophora collected from Lake Ontario.

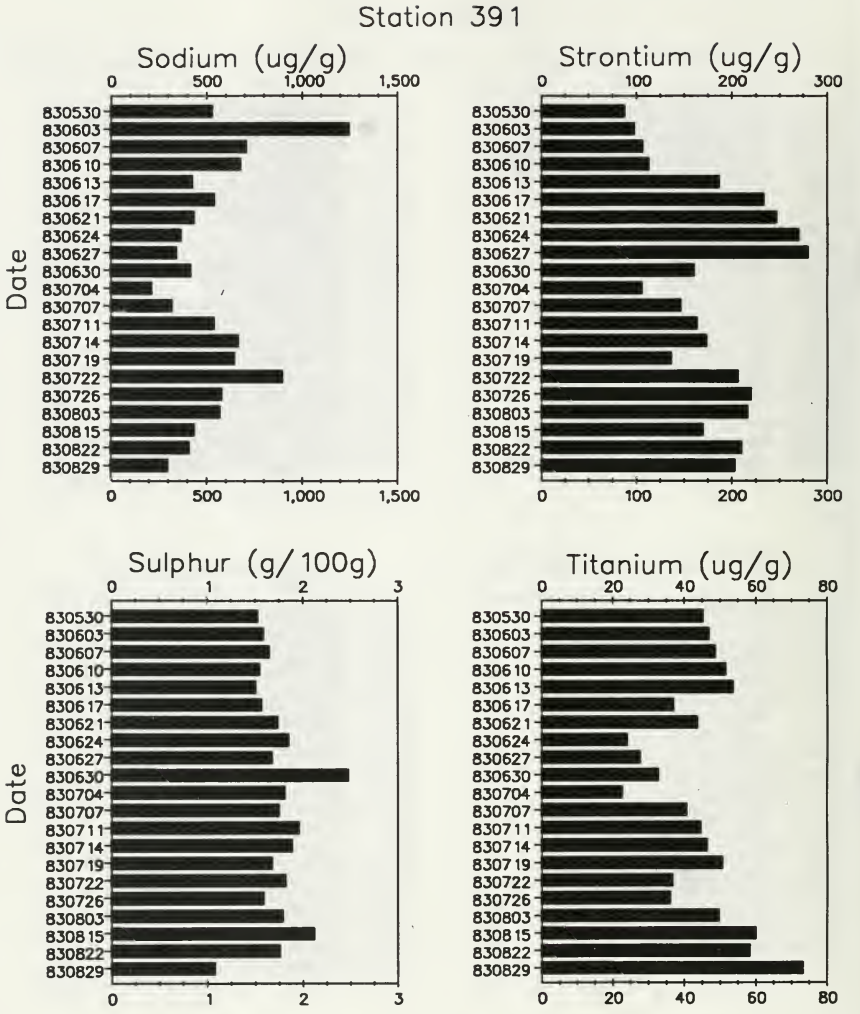


Figure Ont.36: Elemental concentrations in Cladophora collected from Lake Ontario.

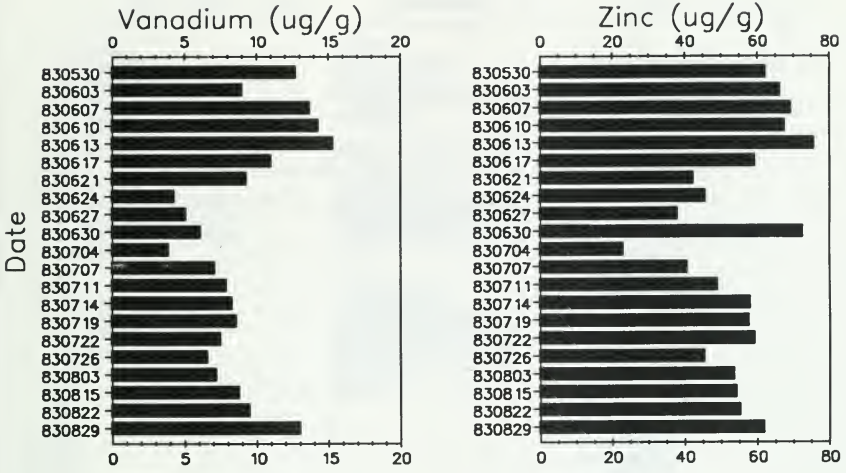


Figure Ont.37: Elemental concentrations in Cladophora collected from Lake Ontario.

III. Niagara River, 400 Series:

Elemental concentrations in *Cladophora* collected from Niagara River at stations 401-422, 424-431 and 438-458, for the years 1981-1985 and 1987-1989.

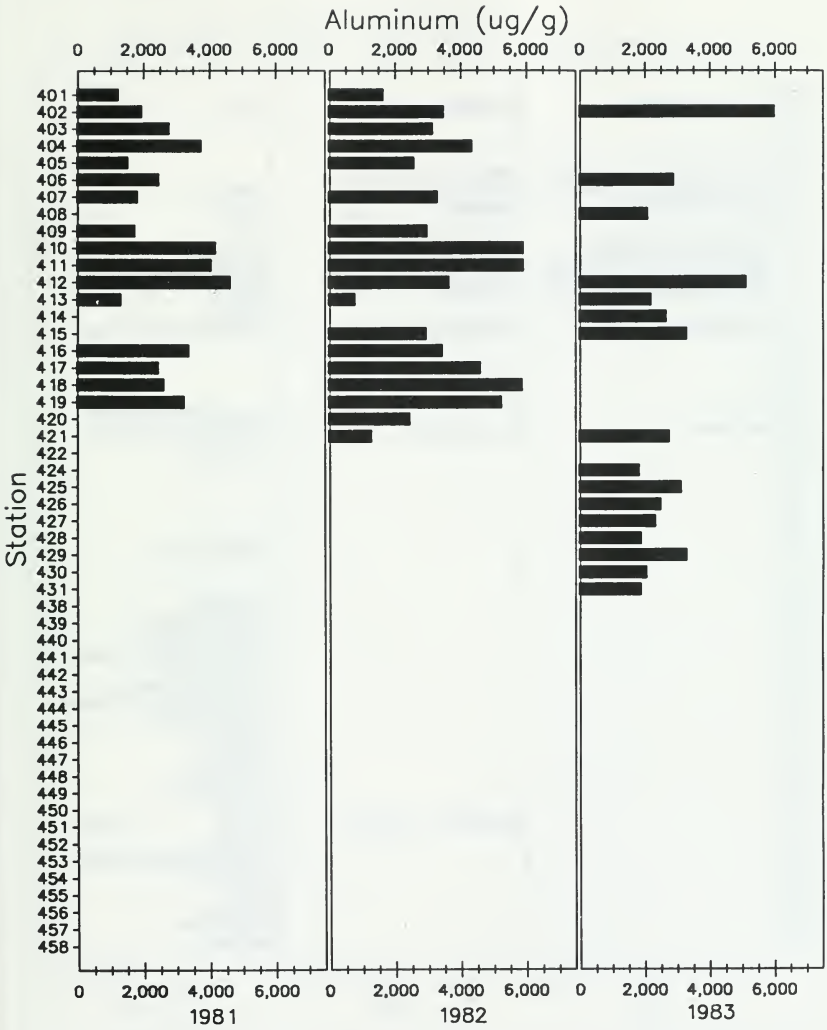


Figure Niag. 1. 1: Elemental concentrations in Cladophora collected from the Niagara River.

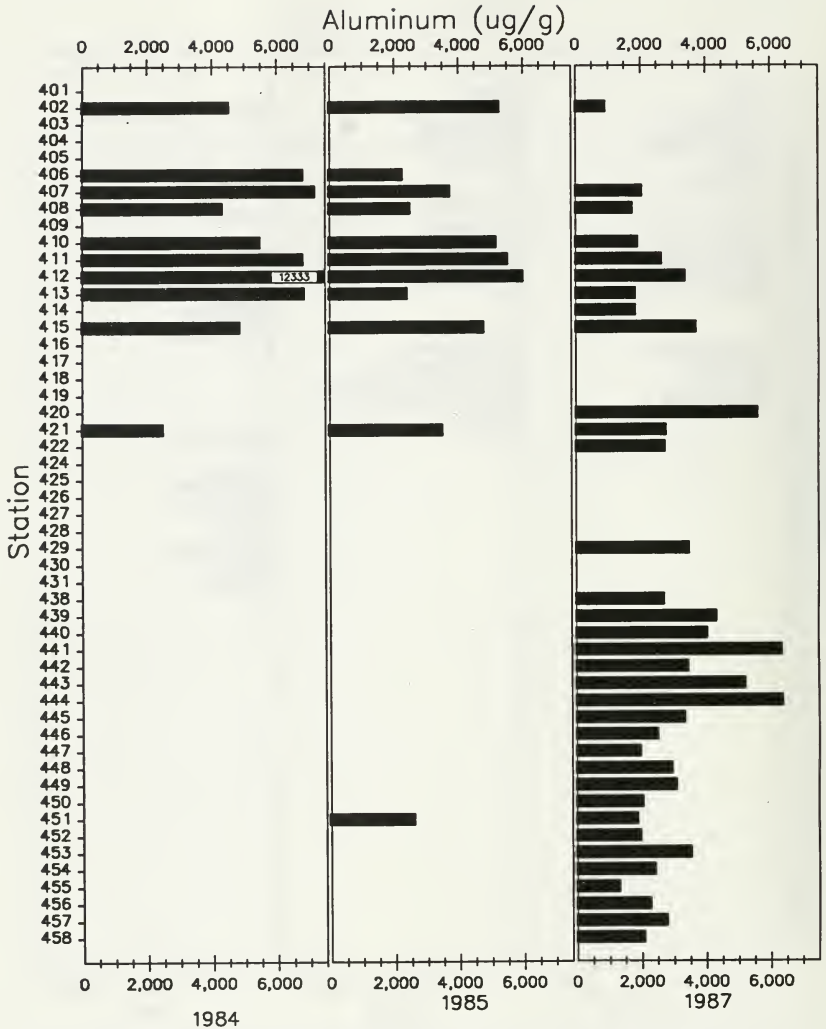


Figure Niag.1.2: Elemental concentrations in Cladophora collected from the Niagara River.

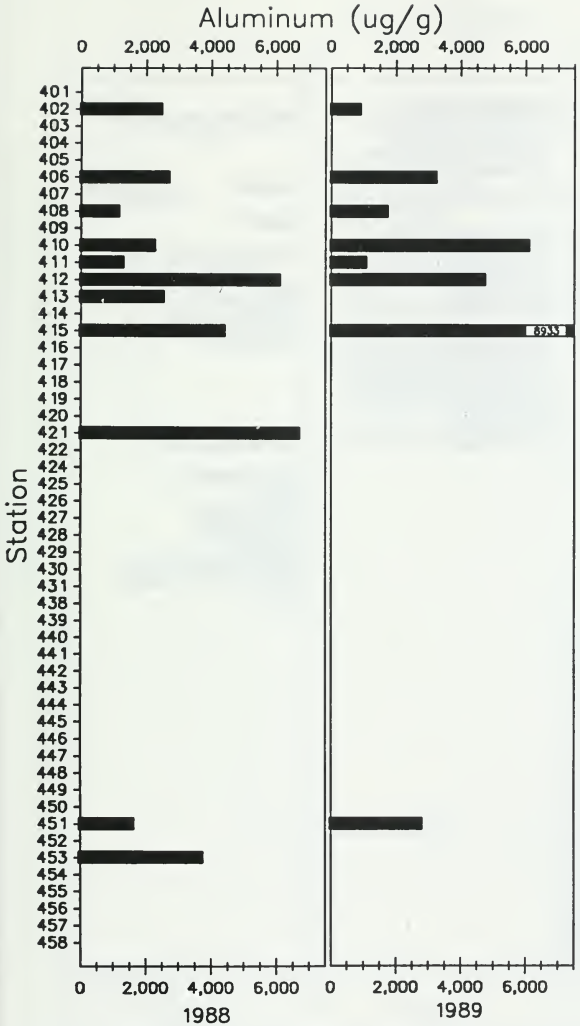


Figure Niag. 1.3: Elemental concentrations in Cladophora collected from the Niagara River.

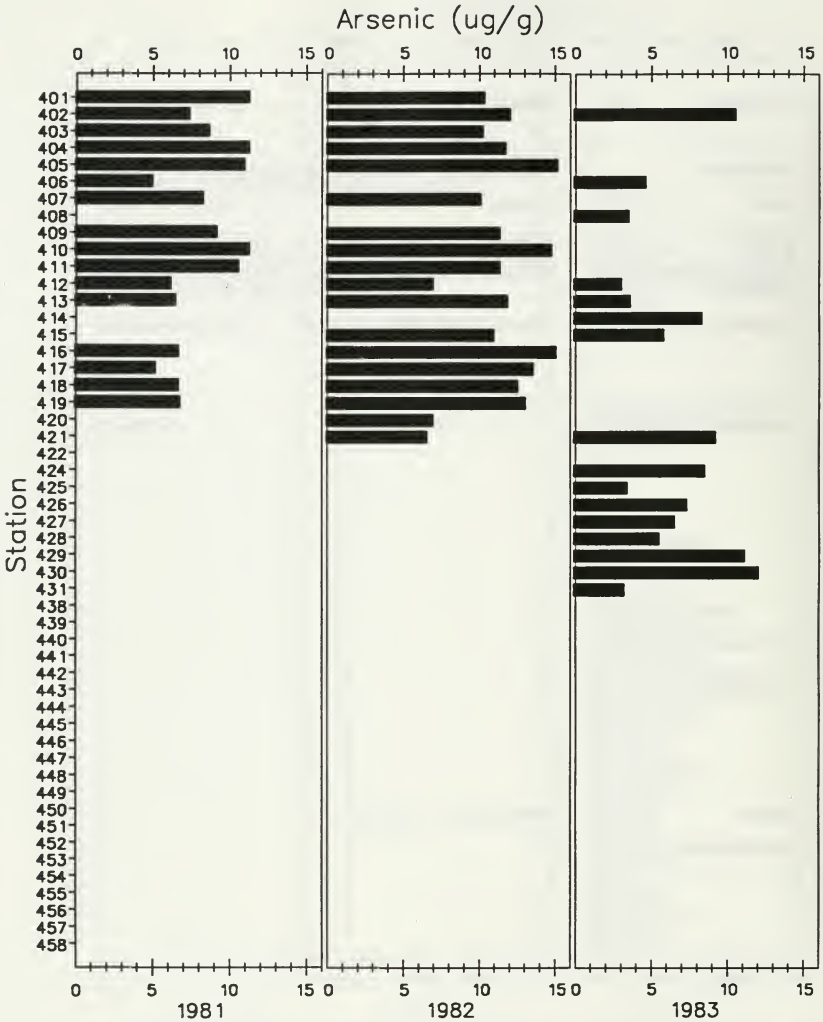


Figure Niag.2.1: Elemental concentrations in Cladophora collected from the Niagara River.

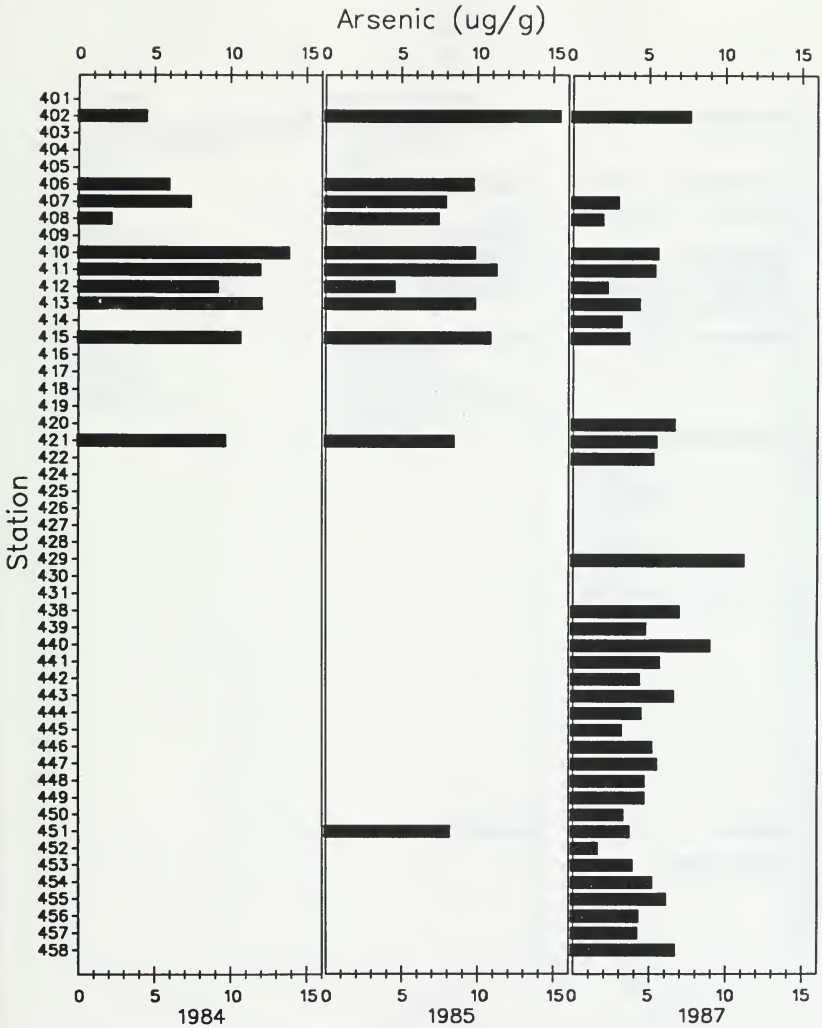


Figure Niag.2.2: Elemental concentrations in Cladophora collected from the Niagara River.

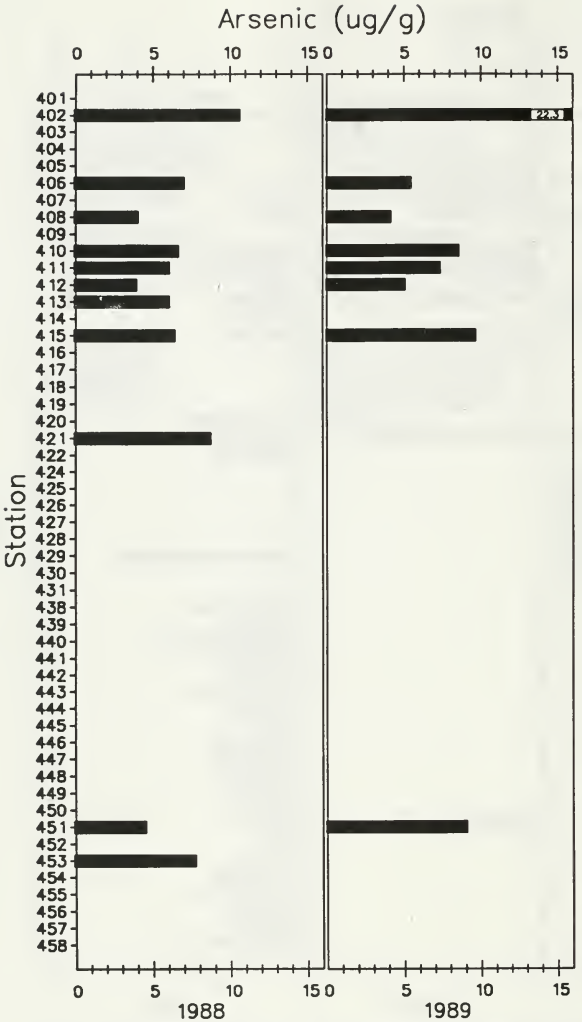


Figure Niag.2.3: Elemental concentrations in Cladophora collected from the Niagara River.

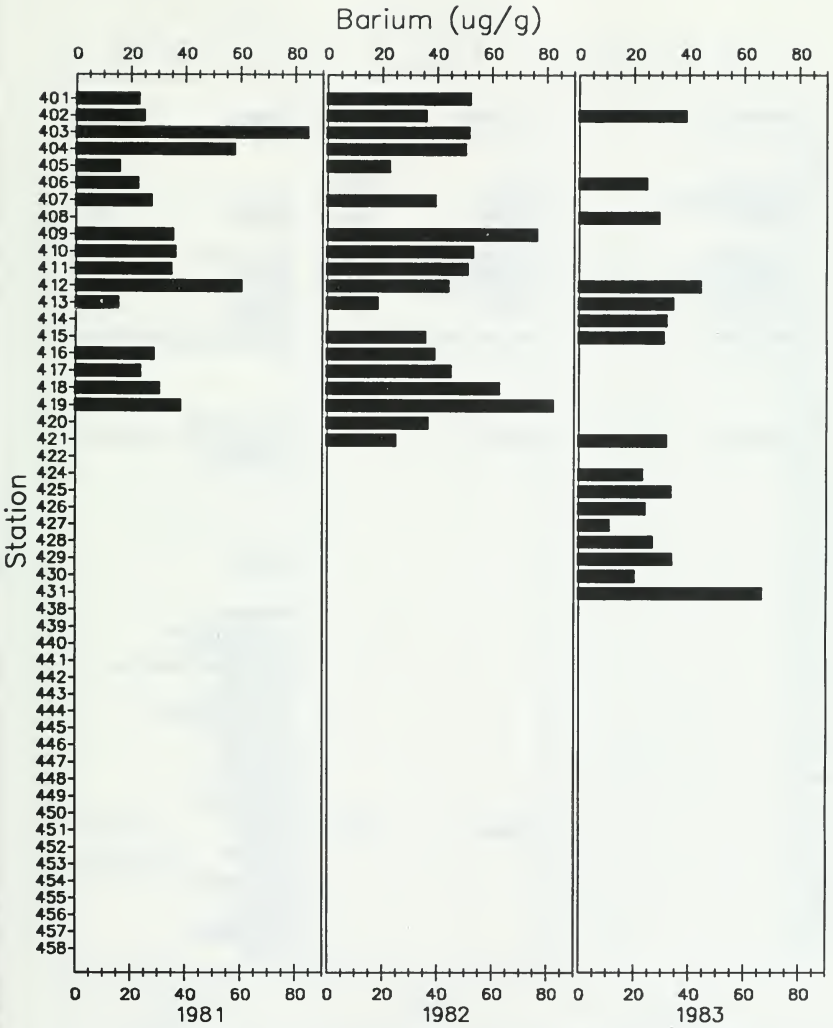


Figure Niag.3.1: Elemental concentrations in Cladophora collected from the Niagara River.

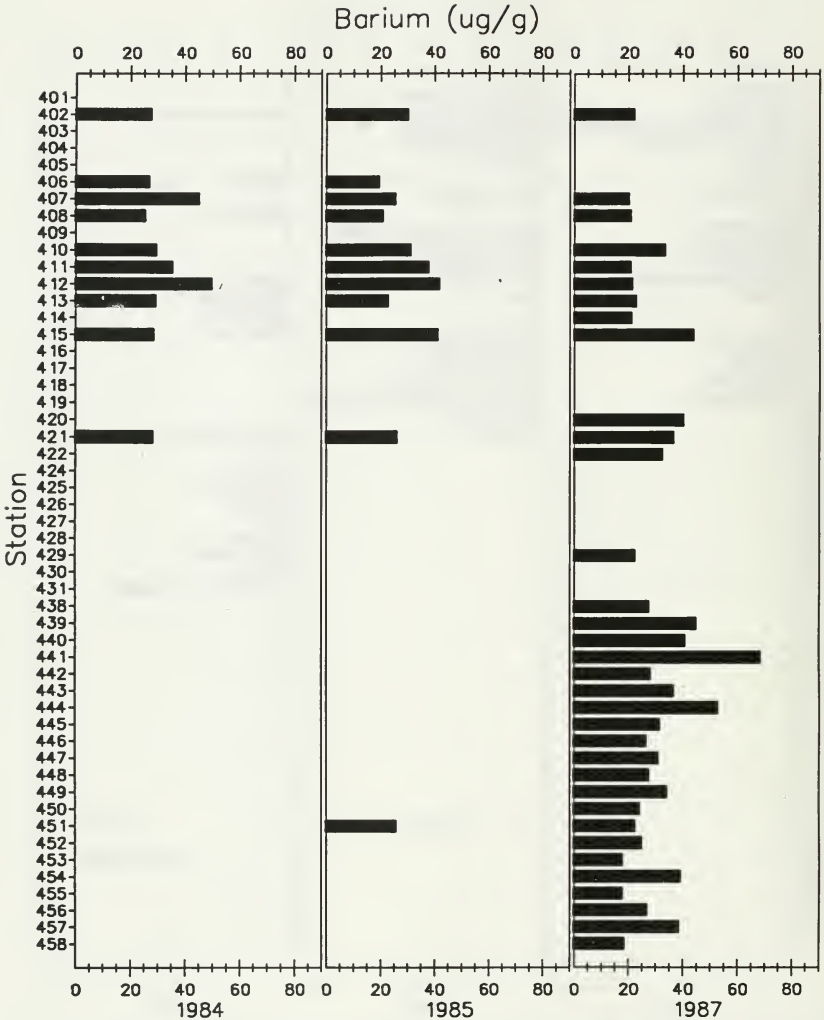


Figure Niag.3.2: Elemental concentrations in Cladophora collected from the Niagara River.

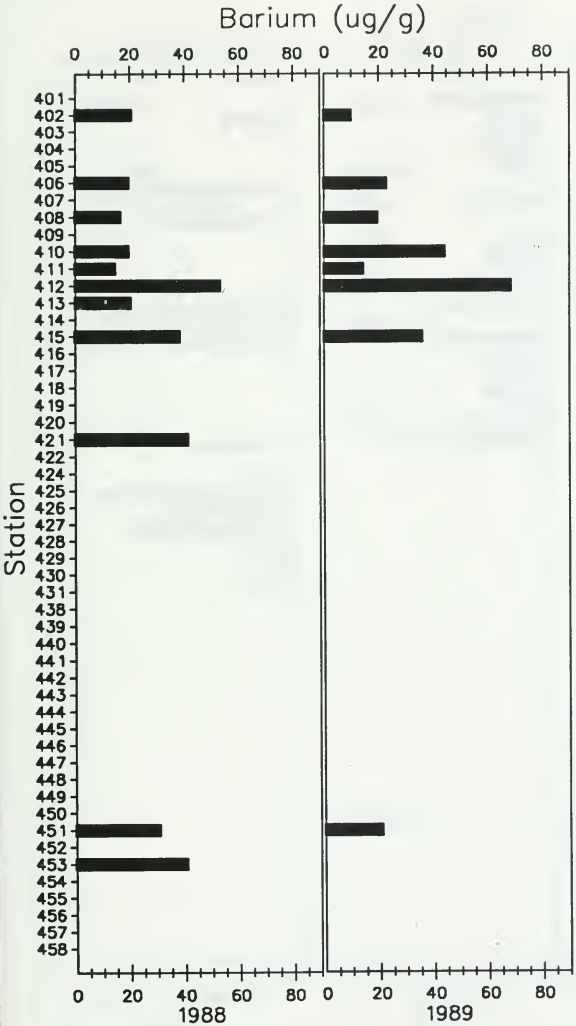


Figure Niag.3.3: Elemental concentrations in Cladophora collected from the Niagara River.

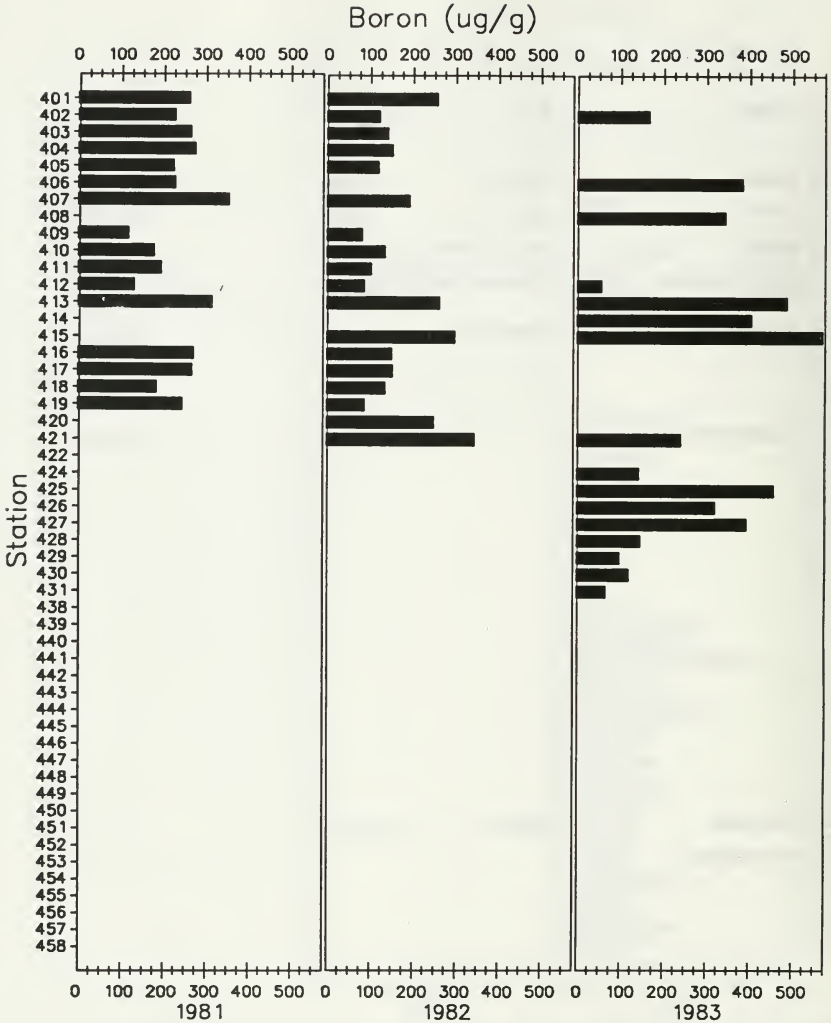


Figure Niag.4.1: Elemental concentrations in Cladophora collected from the Niagara River.

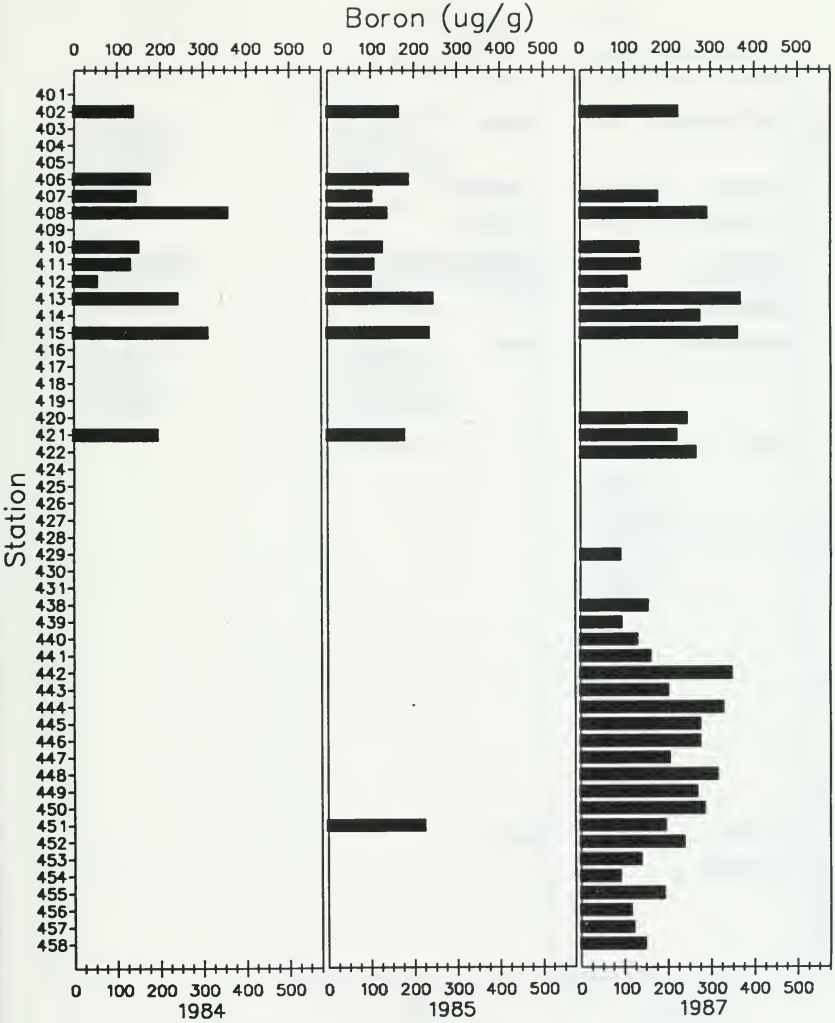


Figure Niag.4.2: Elemental concentrations in Cladophora collected from the Niagara River.

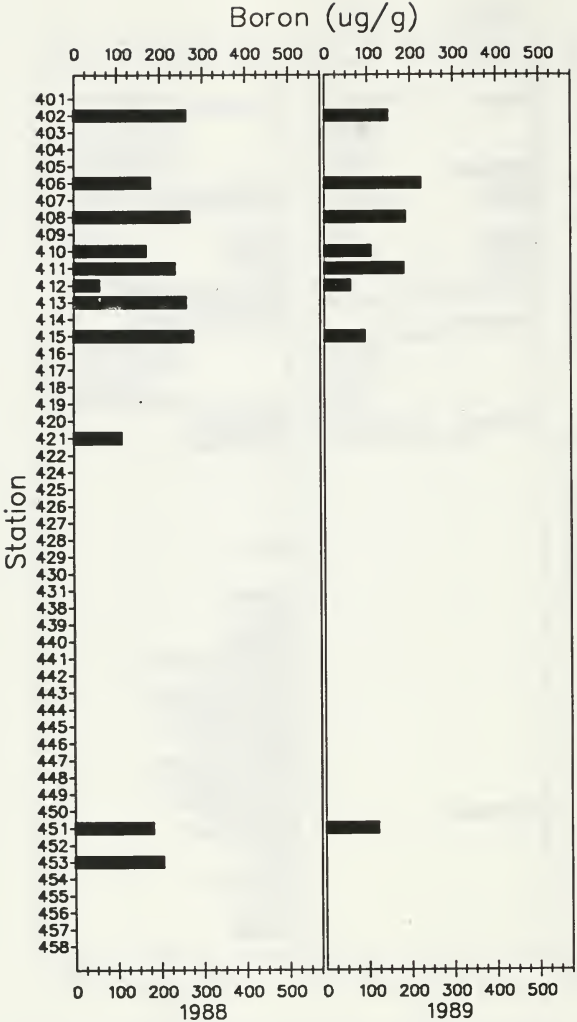


Figure Niag.4.3: Elemental concentrations in Cladophora collected from the Niagara River.

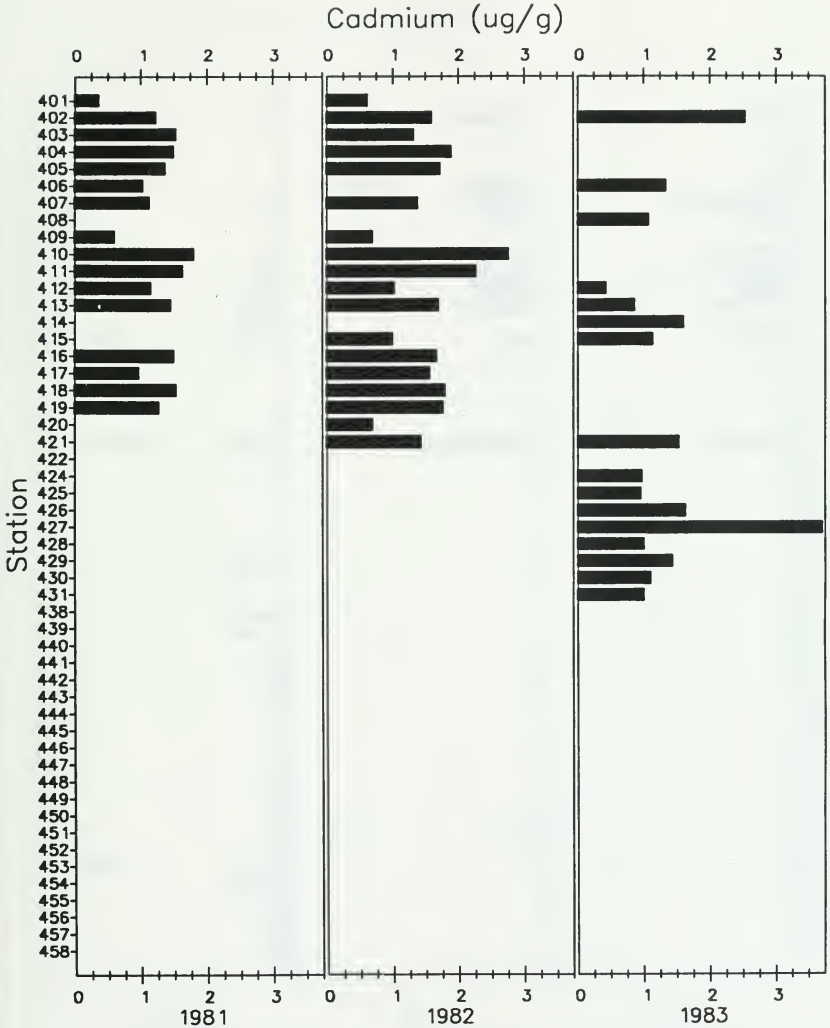


Figure Niag.5.1: Elemental concentrations in Cladophora collected from the Niagara River.

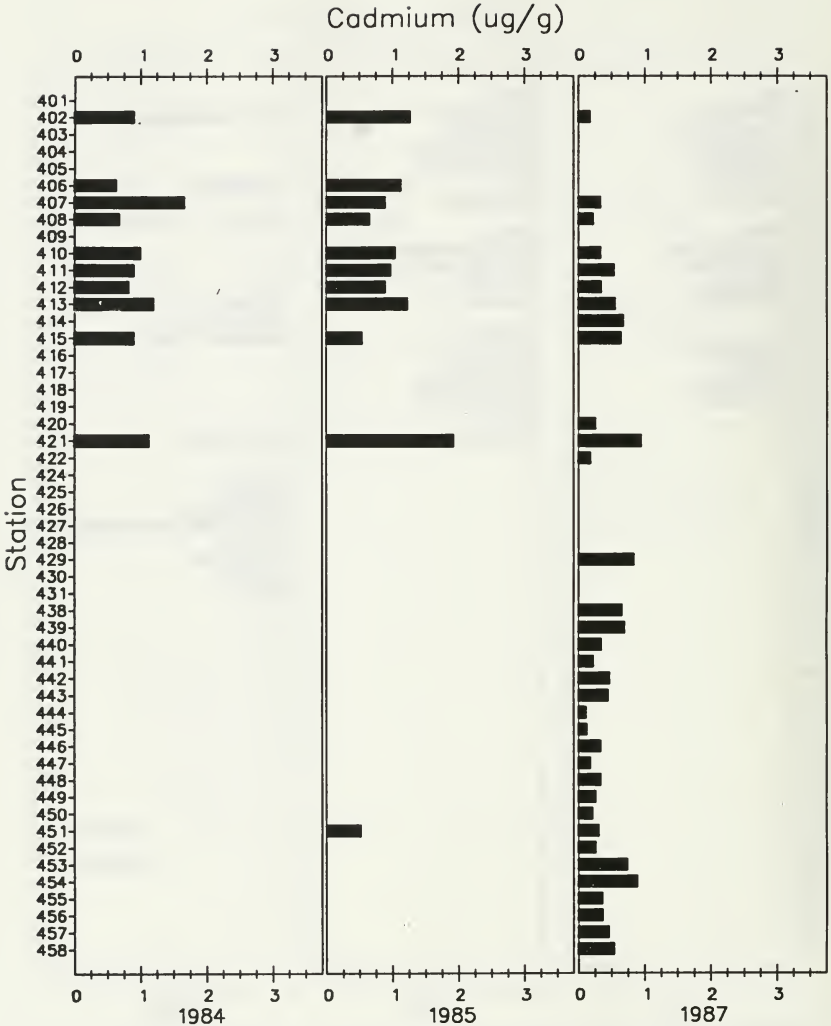


Figure Niag.5.2: Elemental concentrations in Cladophora collected from the Niagara River.

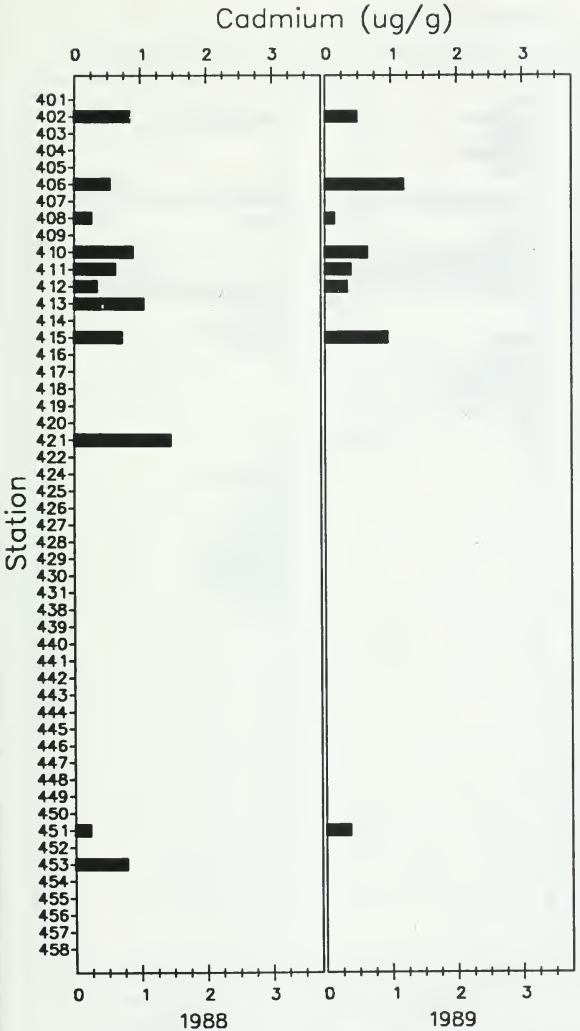


Figure Niag.5.3: Elemental concentrations in Cladophora collected from the Niagara River.

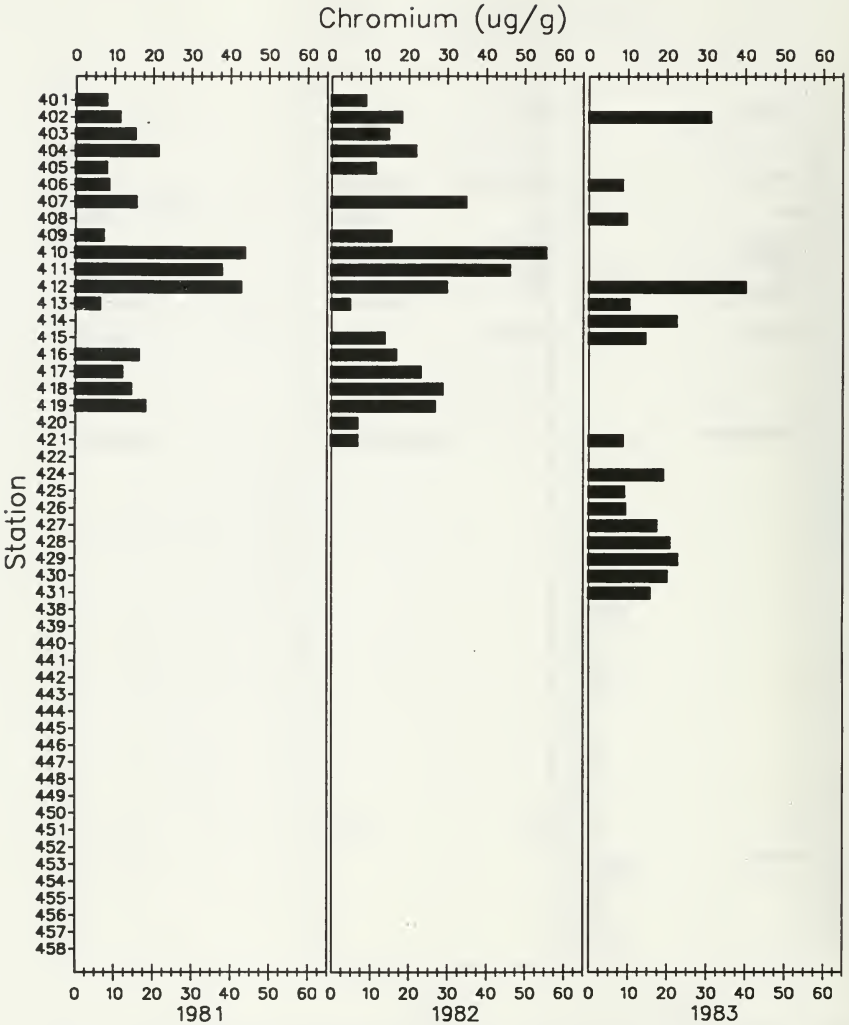


Figure Niag.6.1: Elemental concentrations in Cladophora collected from the Niagara River.

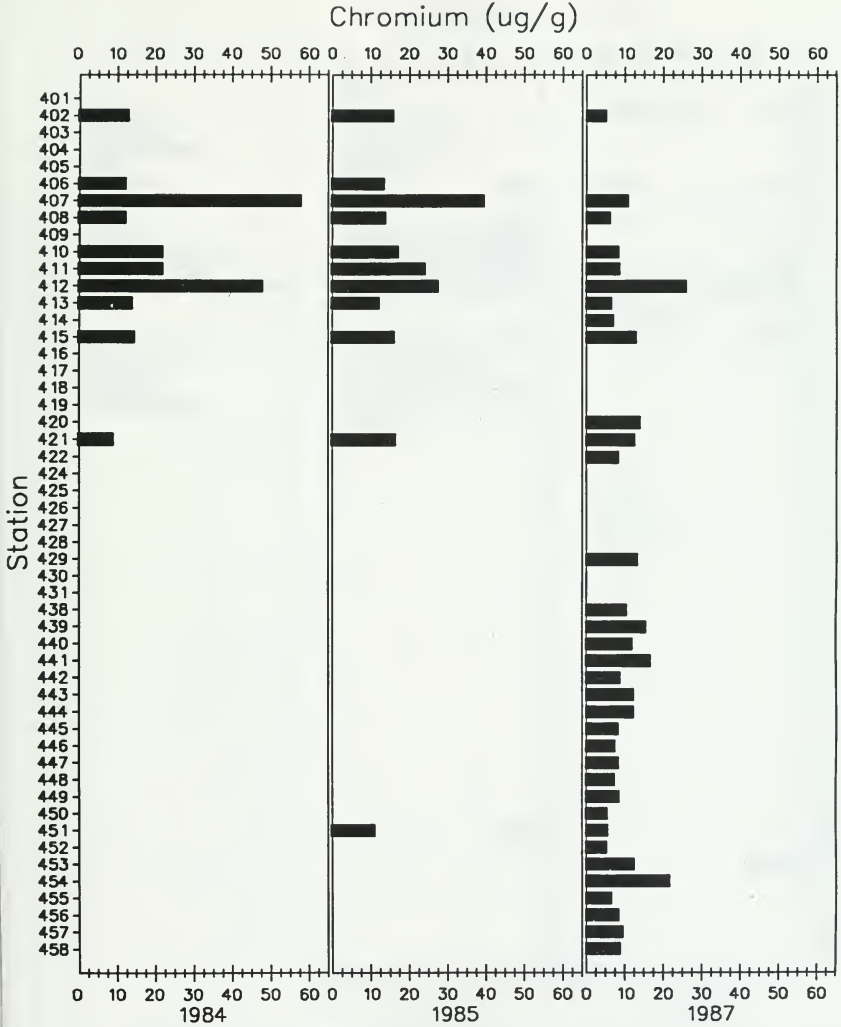


Figure Niag.6.2: Elemental concentrations in Cladophora collected from the Niagara River.

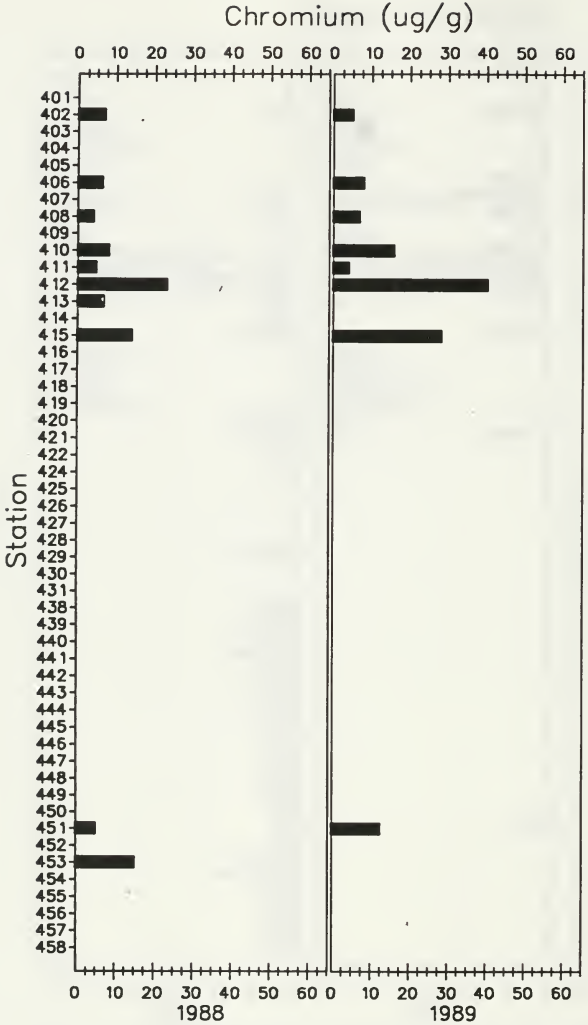


Figure Niag.6.3: Elemental concentrations in Cladophora collected from the Niagara River.

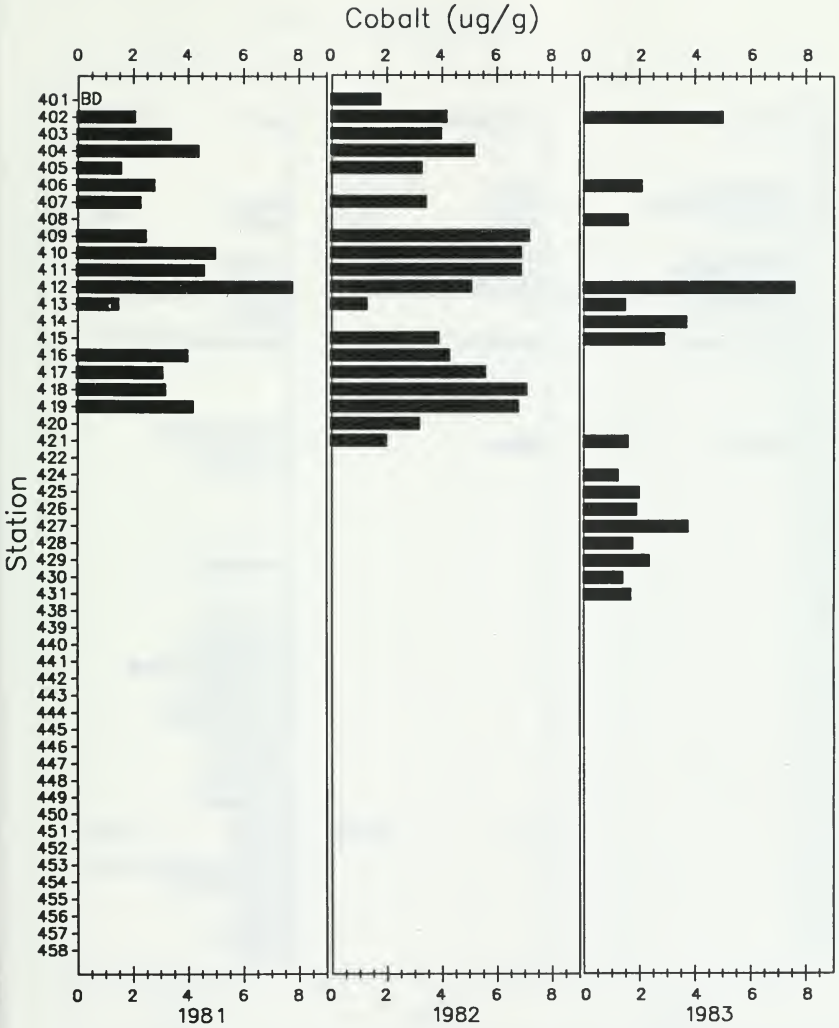


Figure Niag.7.1: Elemental concentrations in Cladophora collected from the Niagara River.

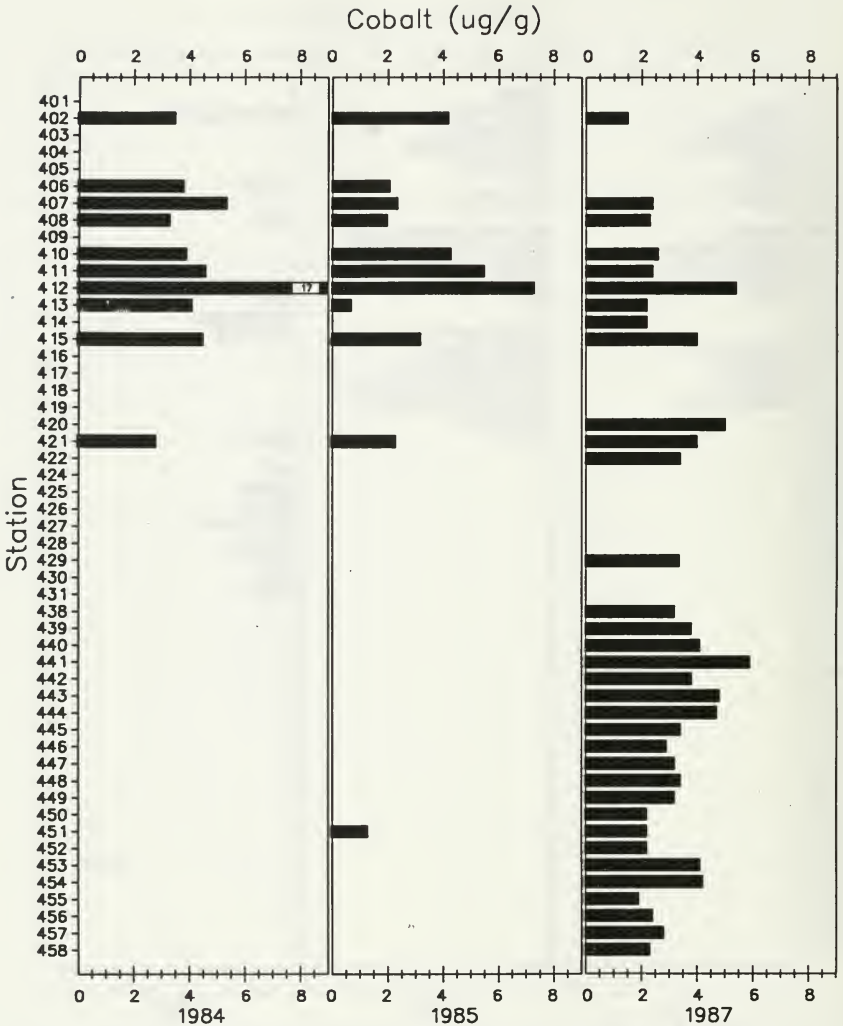


Figure Niag.7.2: Elemental concentrations in Cladophora collected from the Niagara River.

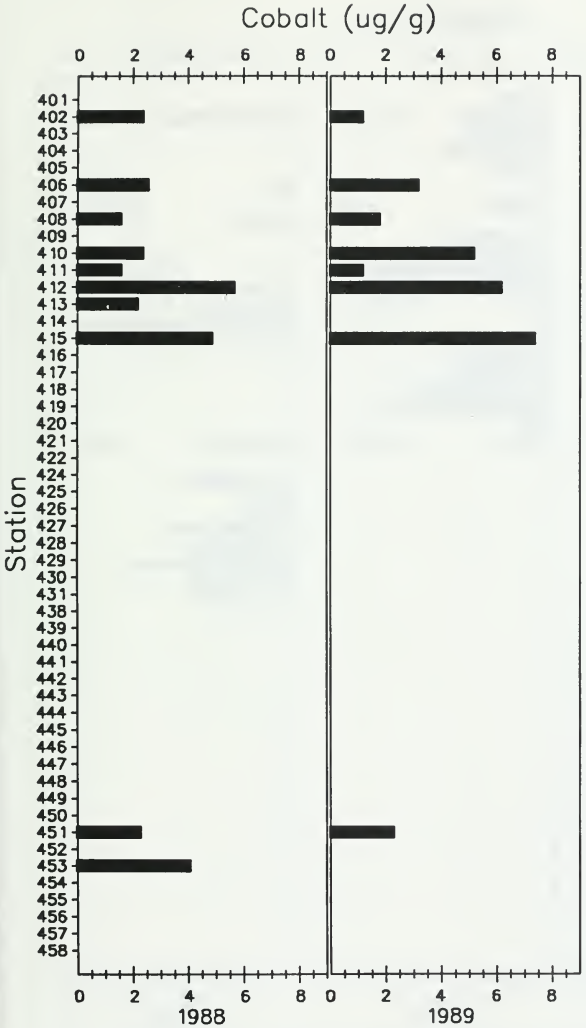


Figure Niag.7.3: Elemental concentrations in Cladophora collected from the Niagara River.

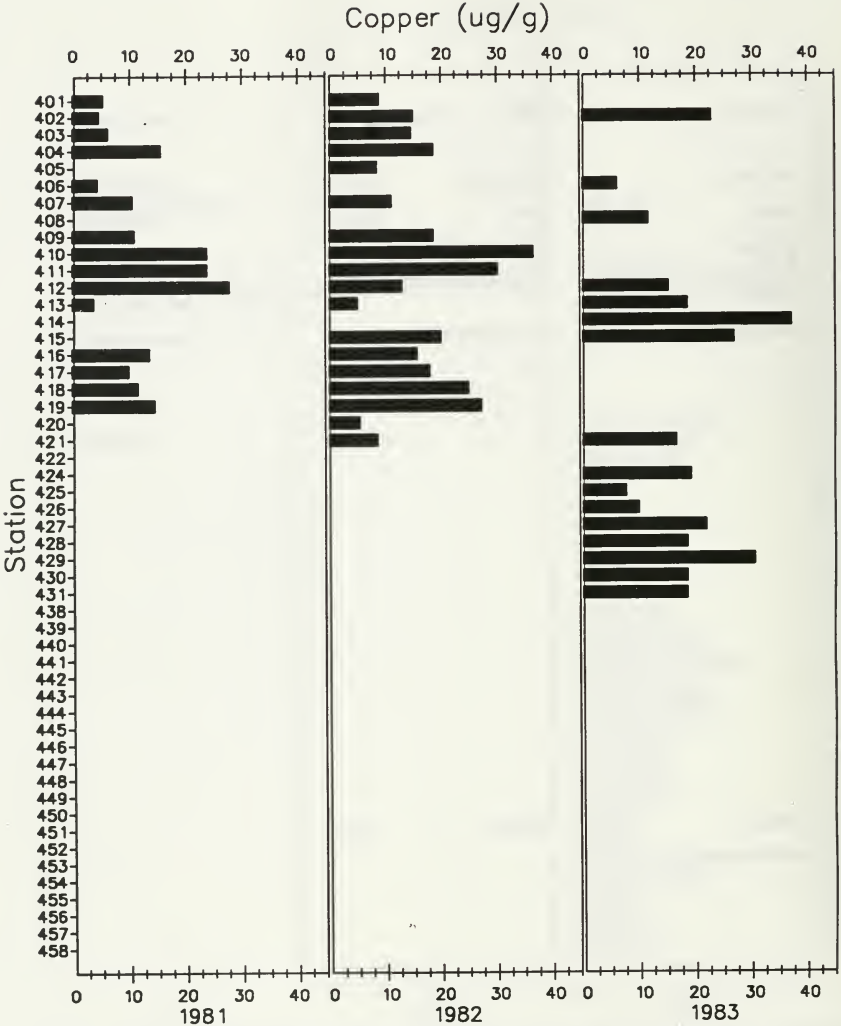


Figure Niag.8.1: Elemental concentrations in Cladophora collected from the Niagara River.

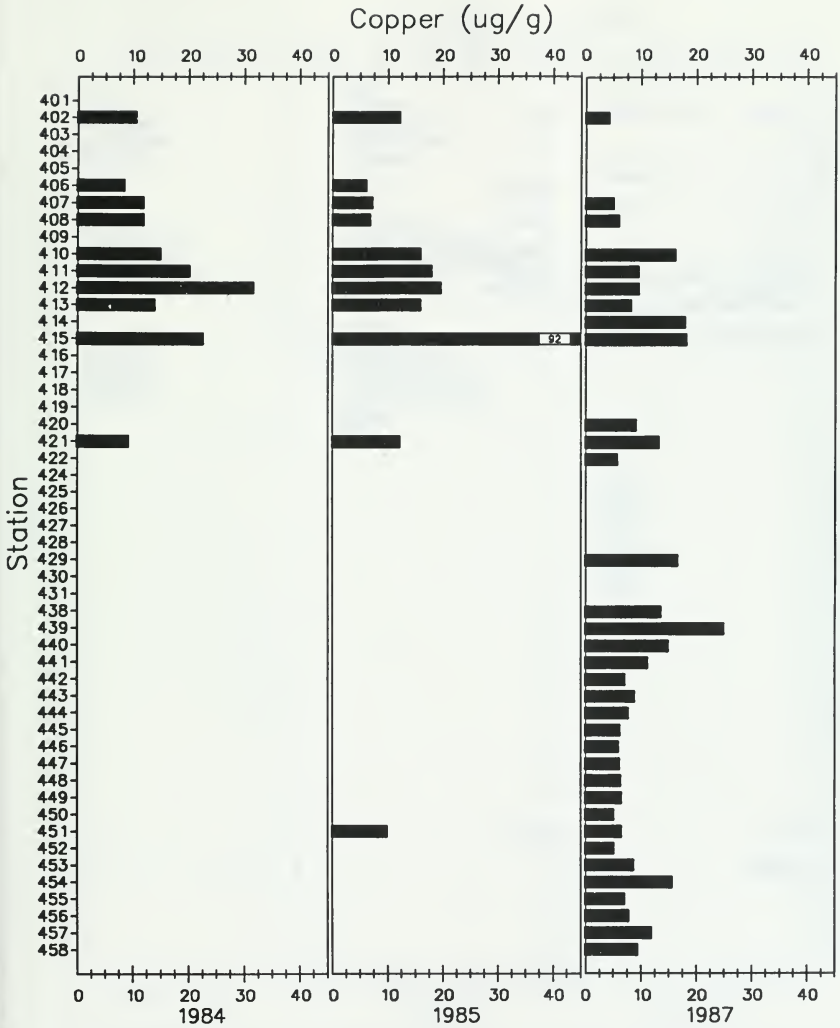


Figure Niag.8.2: Elemental concentrations in Cladophora collected from the Niagara River.

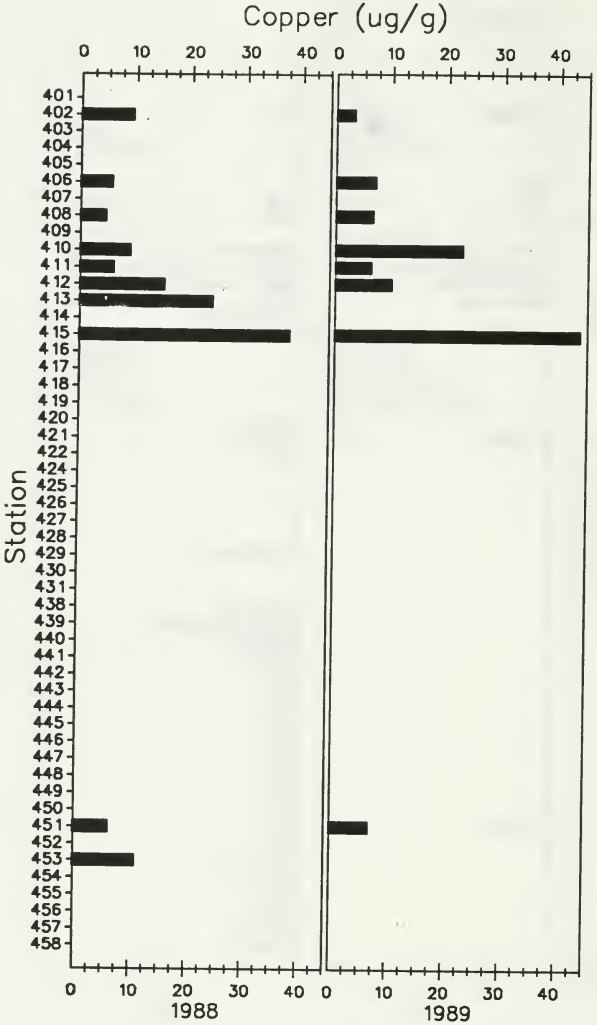


Figure Niag.8.3: Elemental concentrations in Cladophora collected from the Niagara River.

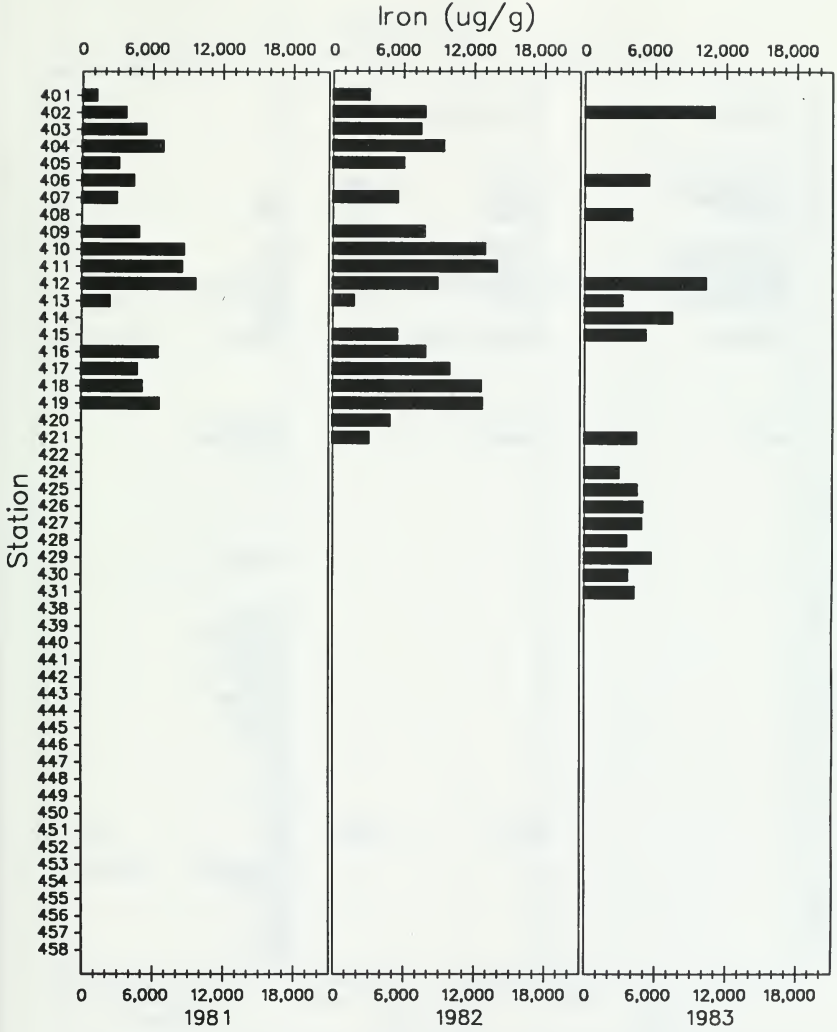


Figure Niag.9.1: Elemental concentrations in Cladophora collected from the Niagara River.

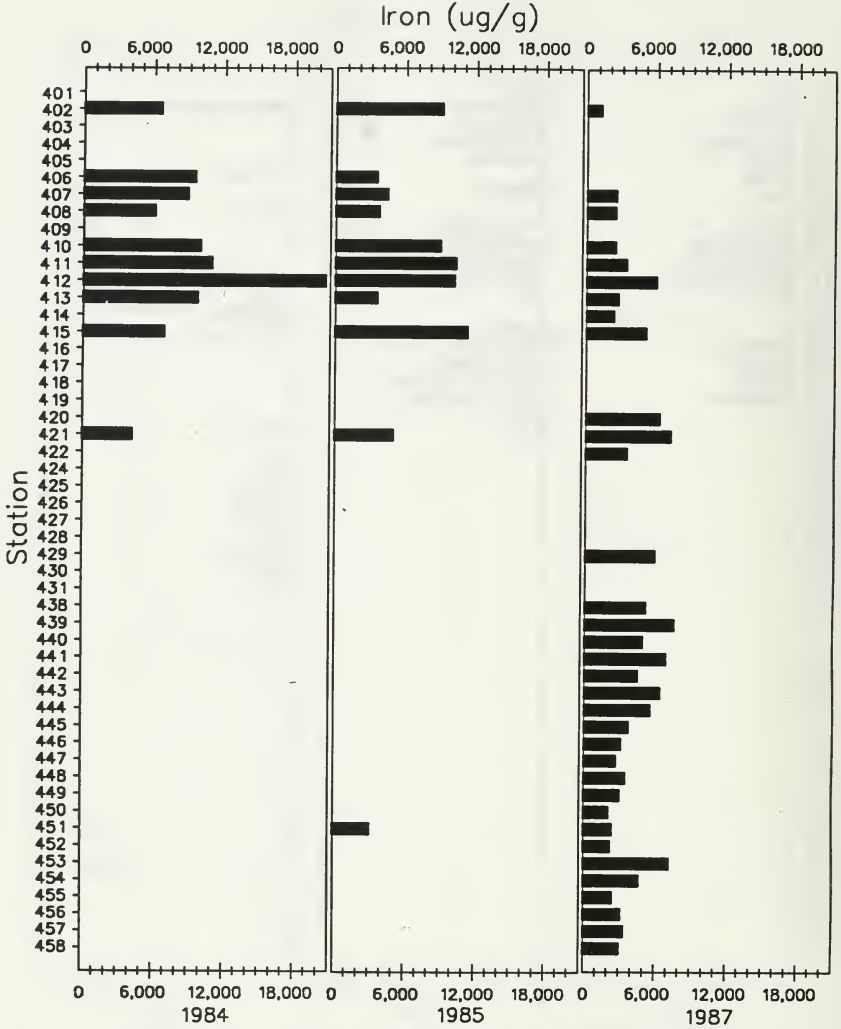


Figure Niag.9.2: Elemental concentrations in Cladophora collected from the Niagara River.

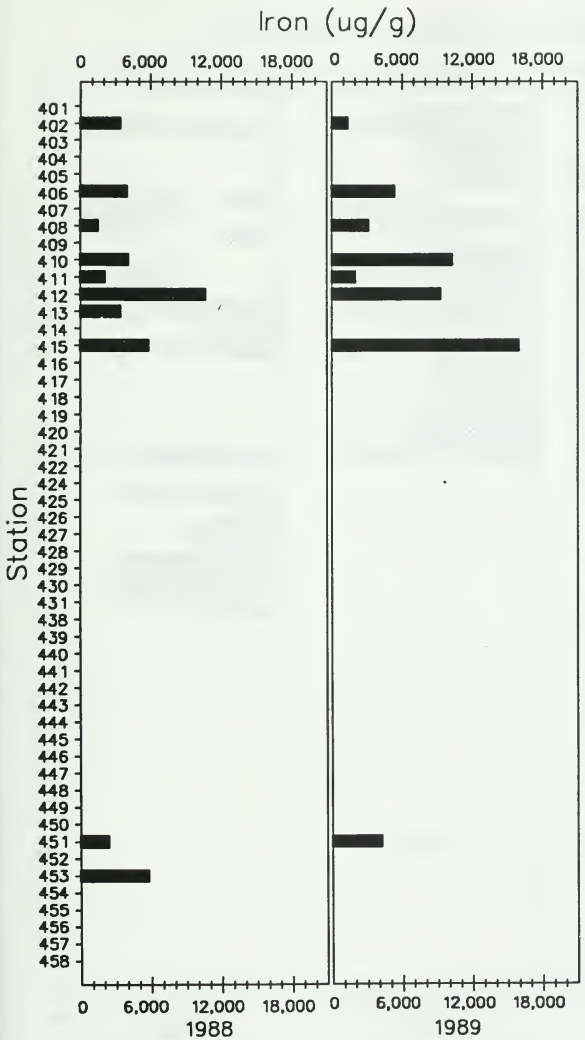


Figure Niag.9.1: Elemental concentrations in Cladophora collected from the Niagara River.

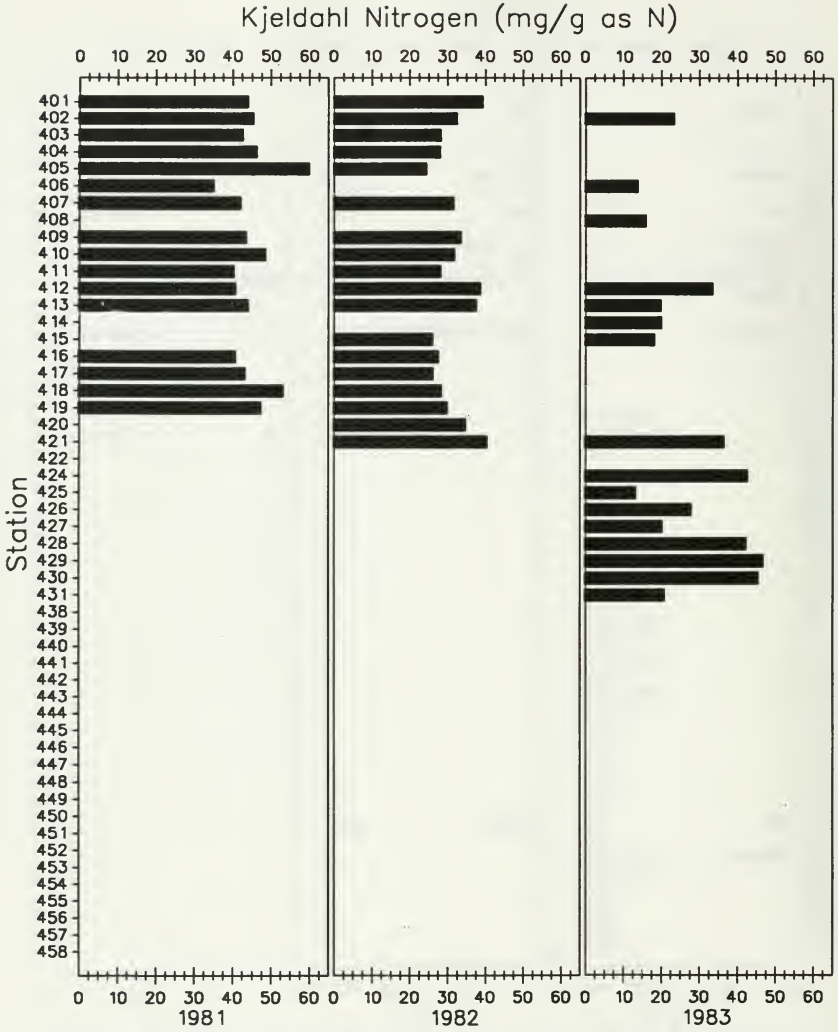


Figure Niag. 10. 1: Elemental concentrations in Cladophora collected from the Niagara River.

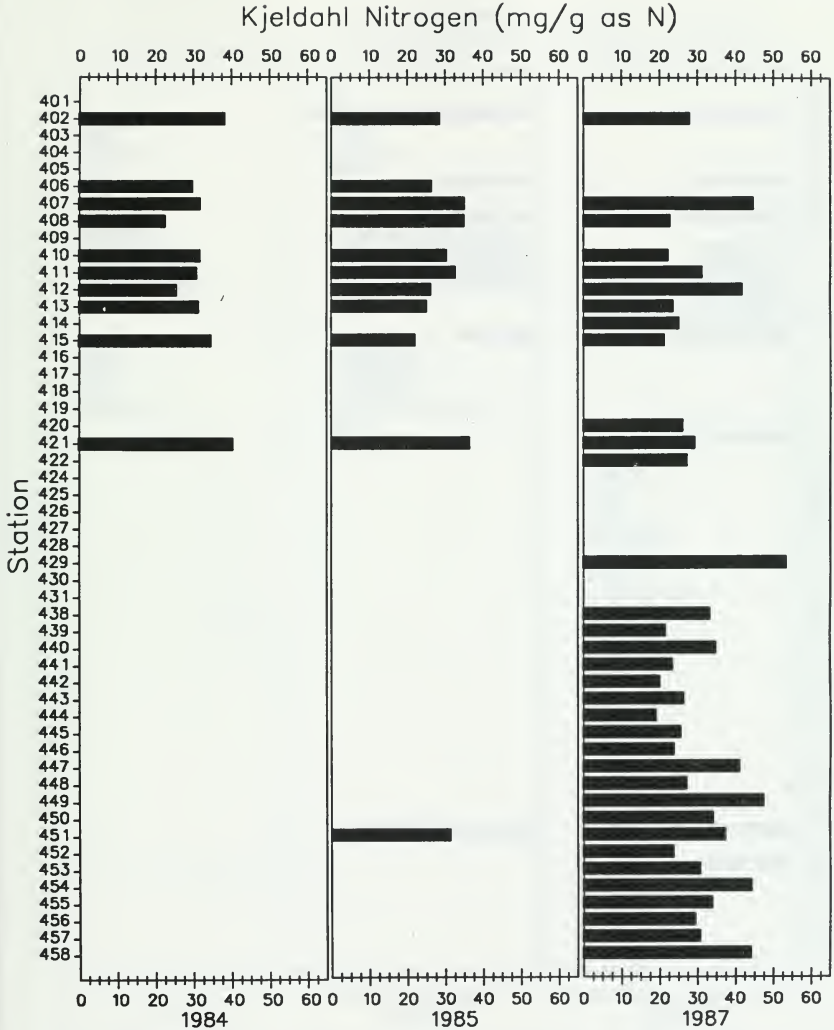


Figure Niag. 10.2: Elemental concentrations in Cladophora collected from the Niagara River.

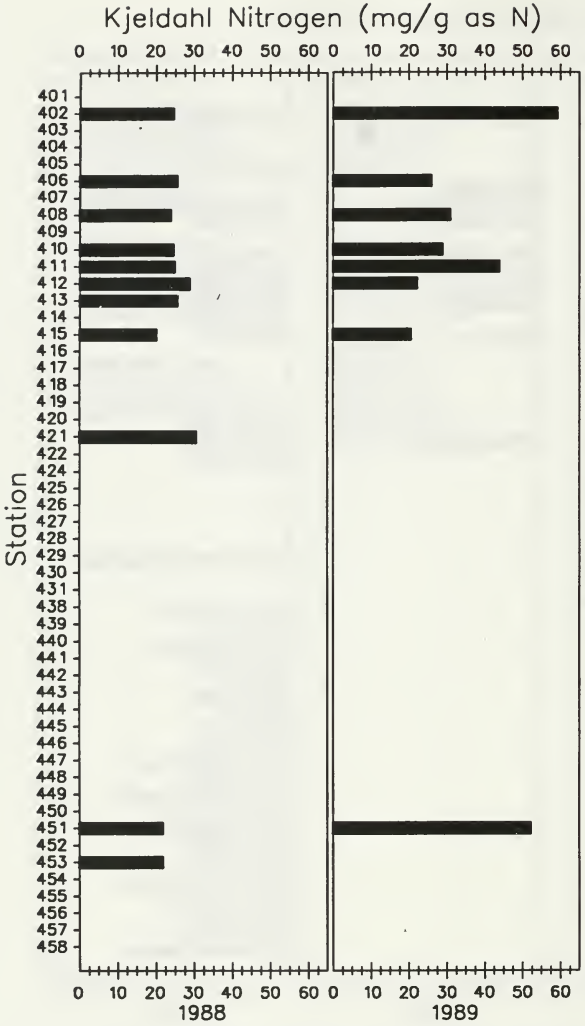


Figure Niag. 10.3: Elemental concentrations in Cladophora collected from the Niagara River.

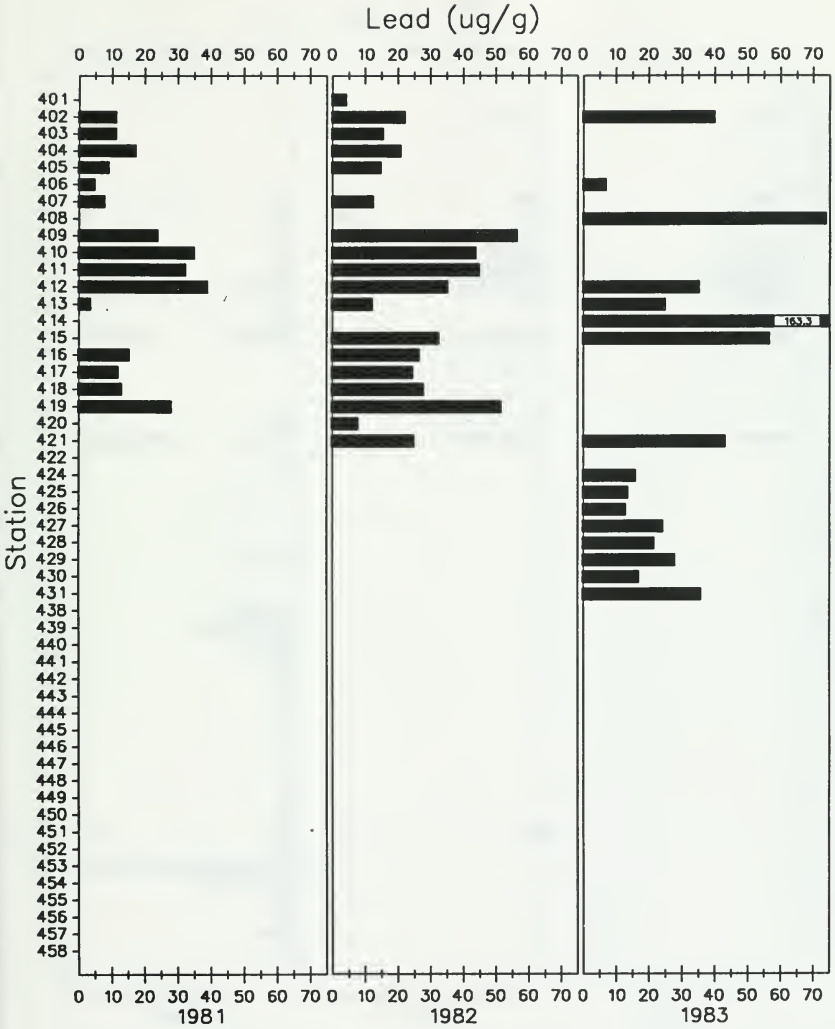


Figure Niag.11.1: Elemental concentrations in Cladophora collected from the Niagara River.

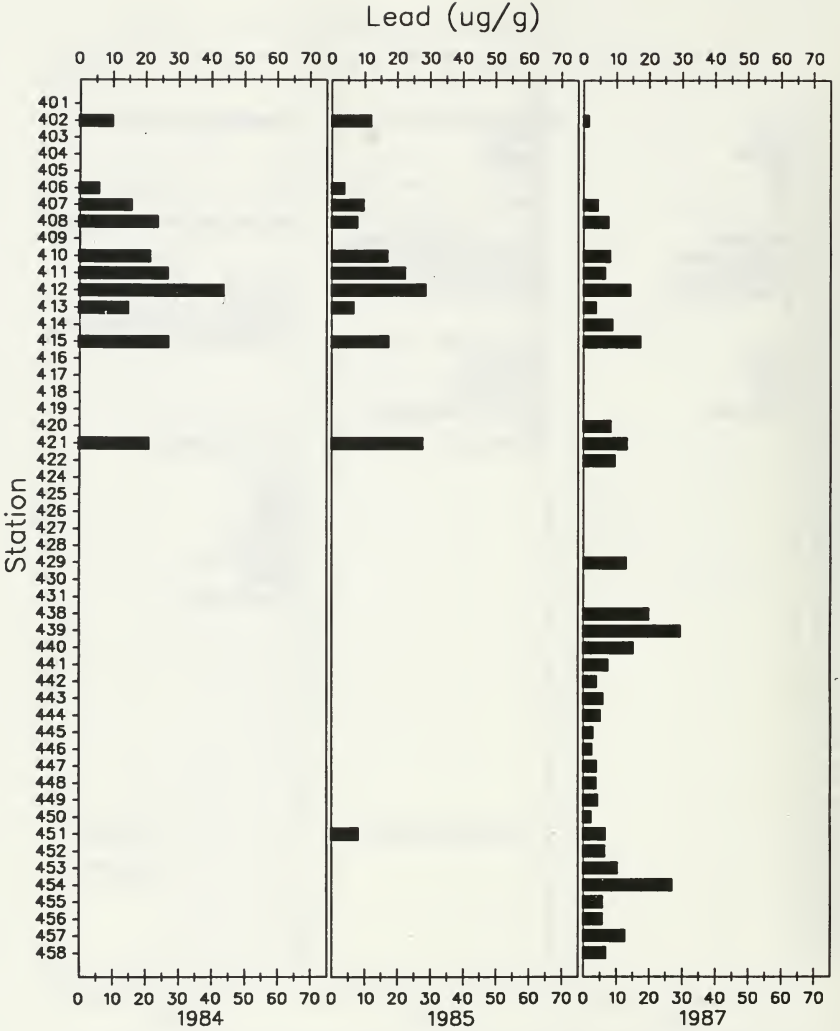


Figure Niag.11.2: Elemental concentrations in Cladophora collected from the Niagara River.

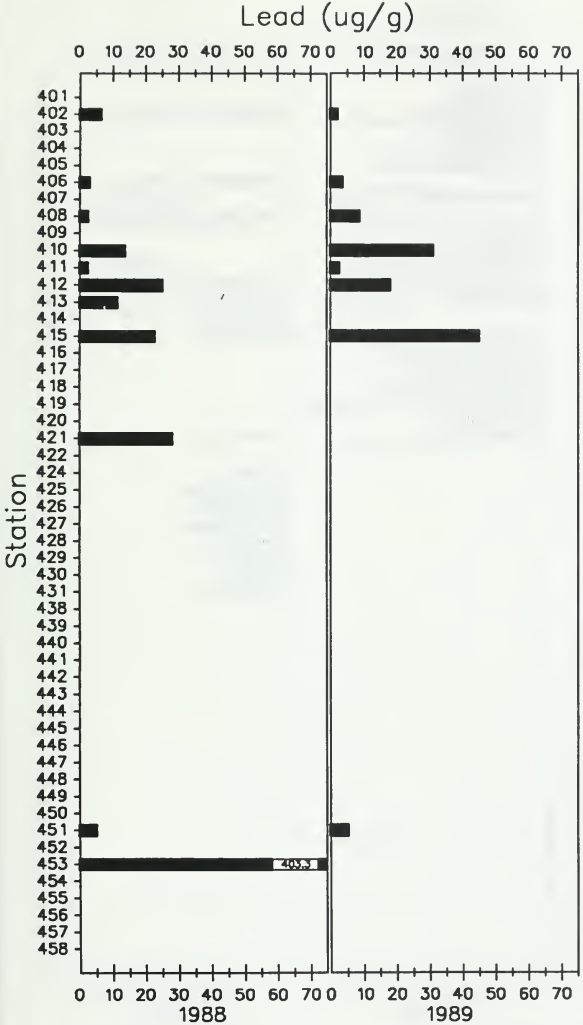


Figure Niag.11.3: Elemental concentrations in Cladophora collected from the Niagara River.

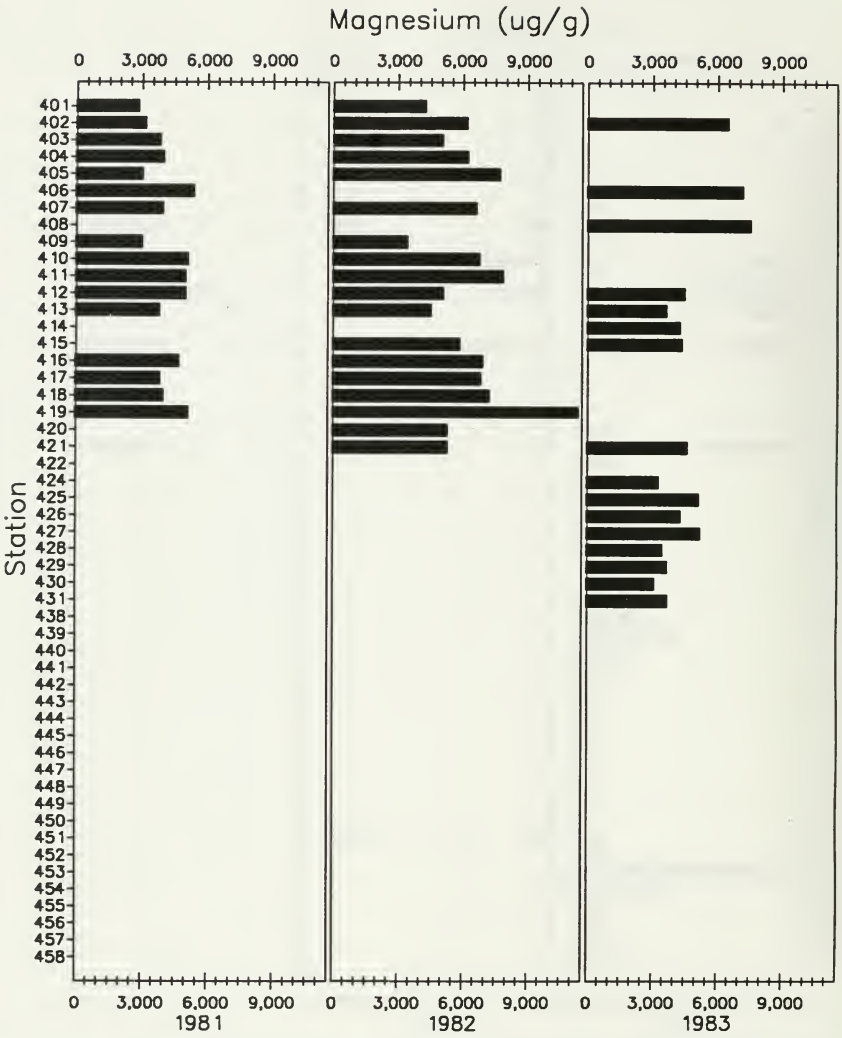


Figure Niag. 12. 1: Elemental concentrations in Cladophora collected from the Niagara River.

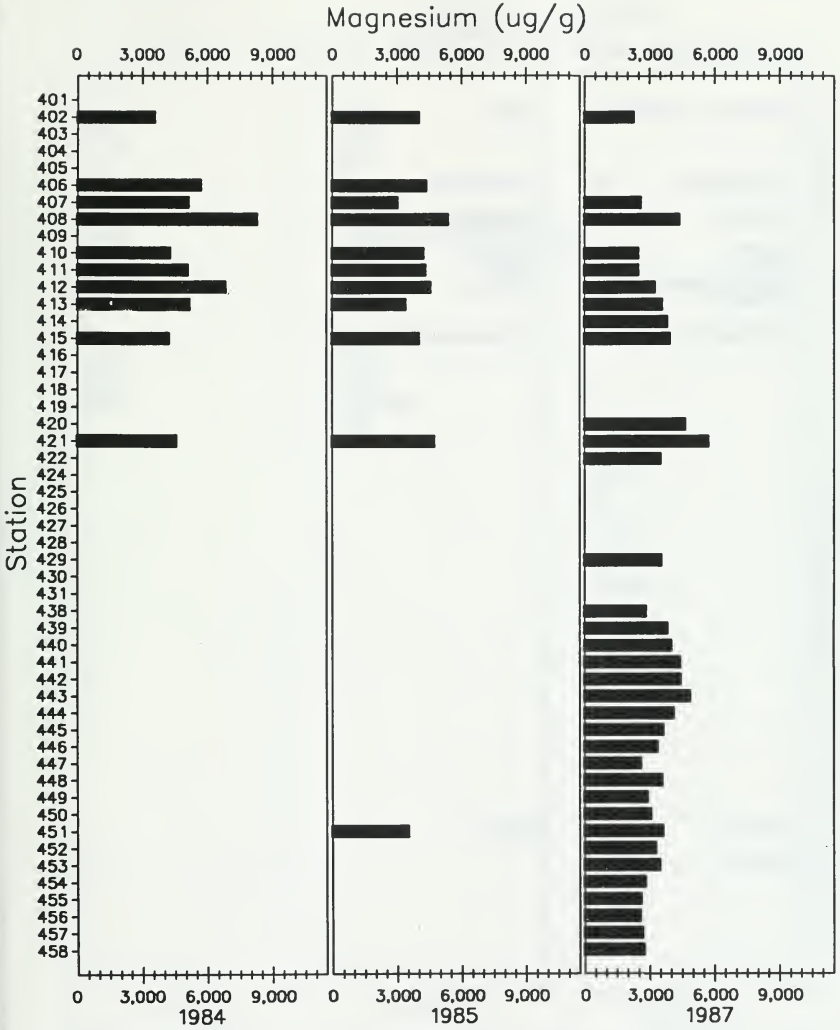


Figure Niag. 12.2: Elemental concentrations in Cladophora collected from the Niagara River.

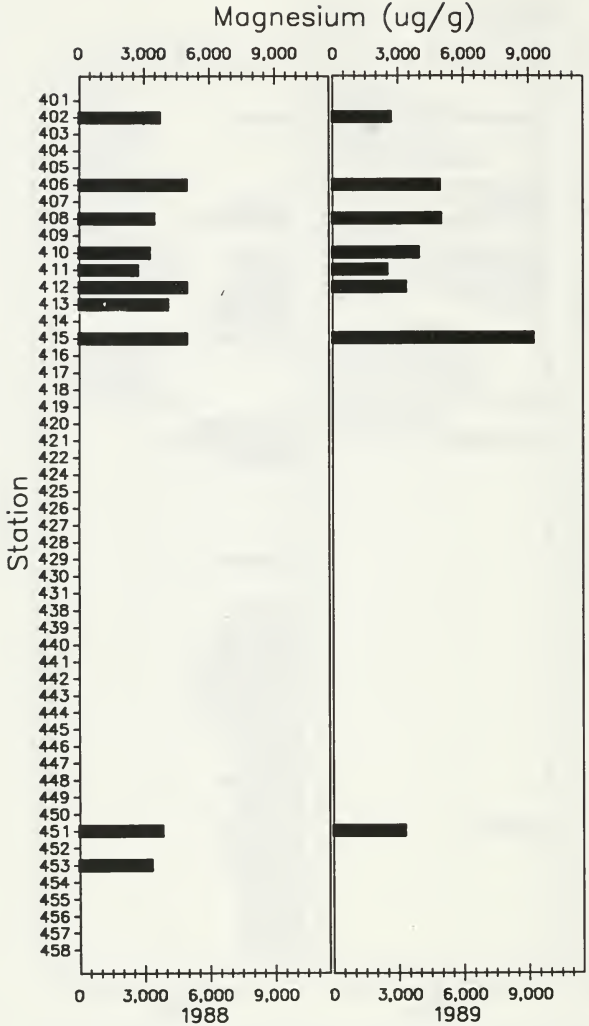


Figure Niag. 12.3: Elemental concentrations in Cladophora collected from the Niagara River.

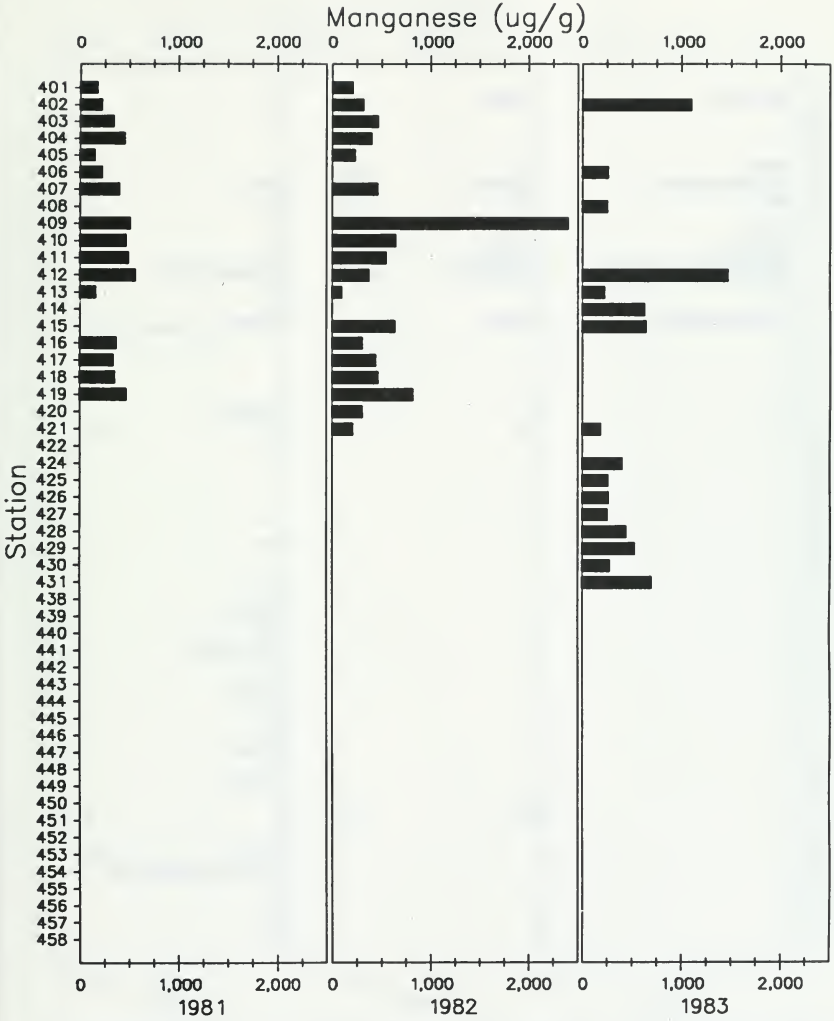


Figure Niag. 13. 1: Elemental concentrations in Cladophora collected from the Niagara River.

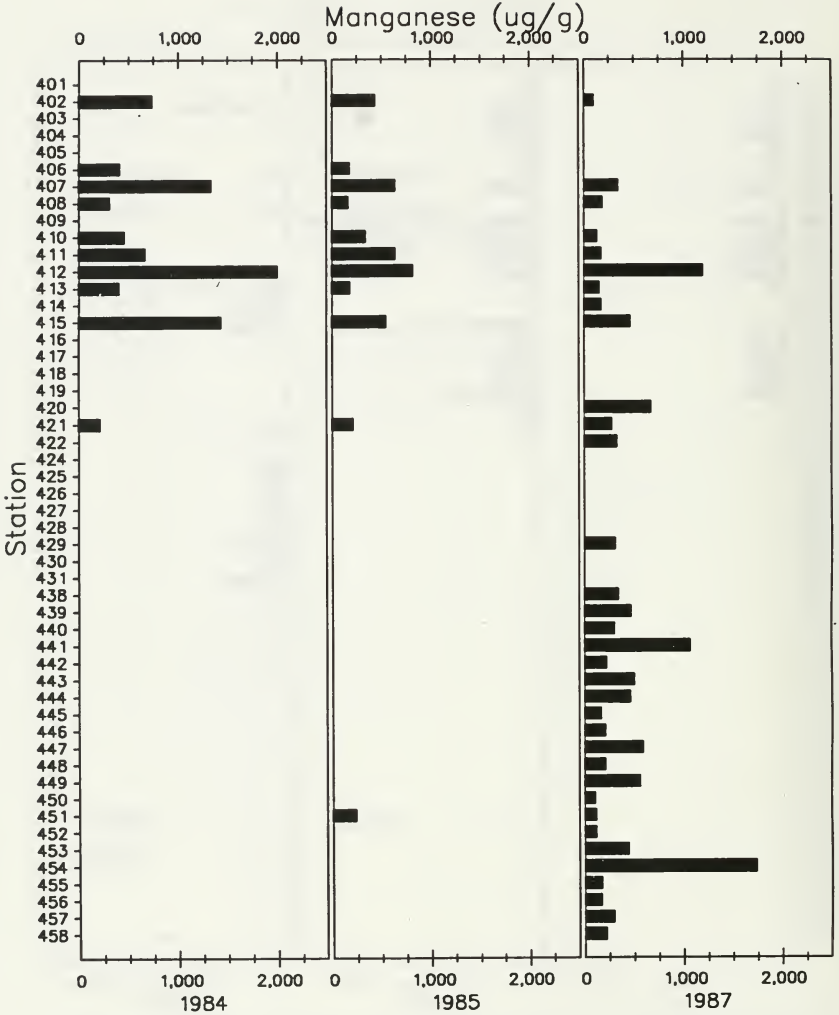


Figure Niag. 13.2: Elemental concentrations in Cladophora collected from the Niagara River.

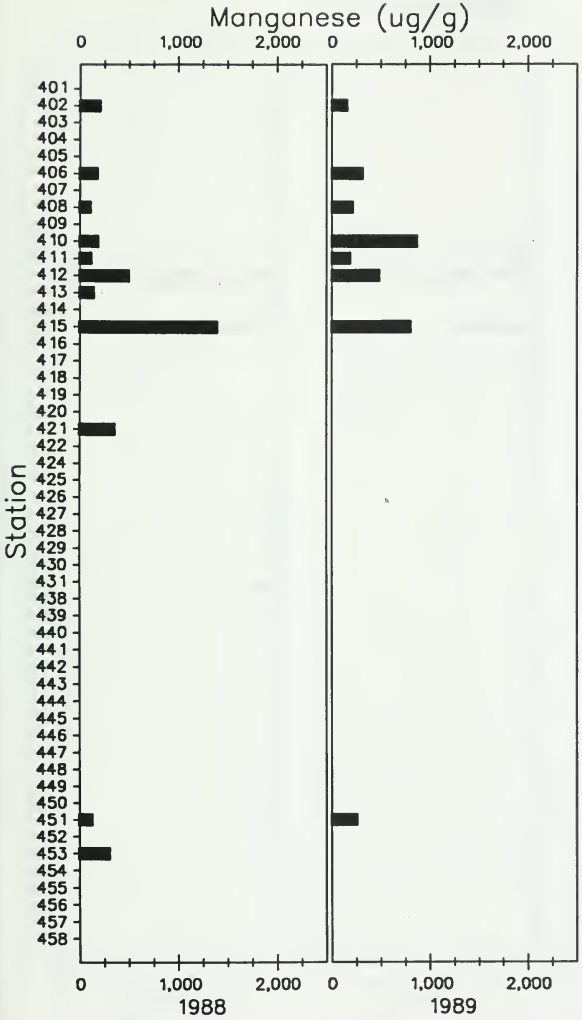


Figure Niag. 13.3: Elemental concentrations in Cladophora collected from the Niagara River.

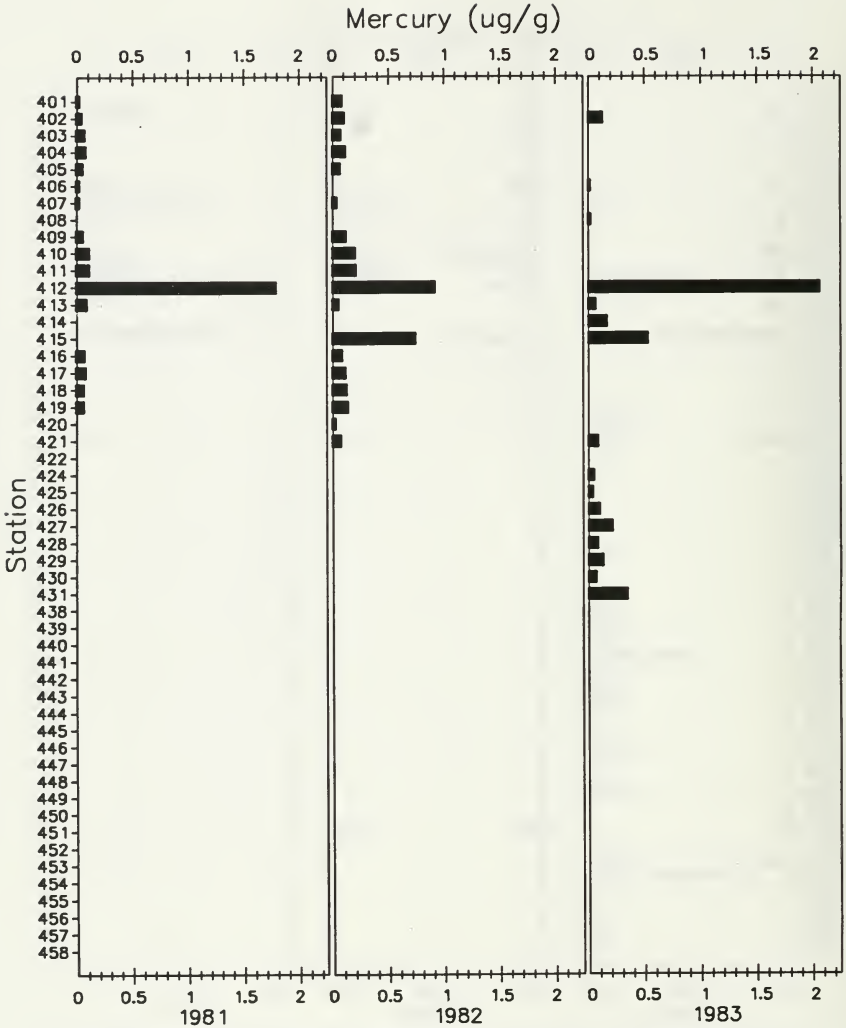


Figure Niag.14.1: Elemental concentrations in Cladophora collected from the Niagara River.

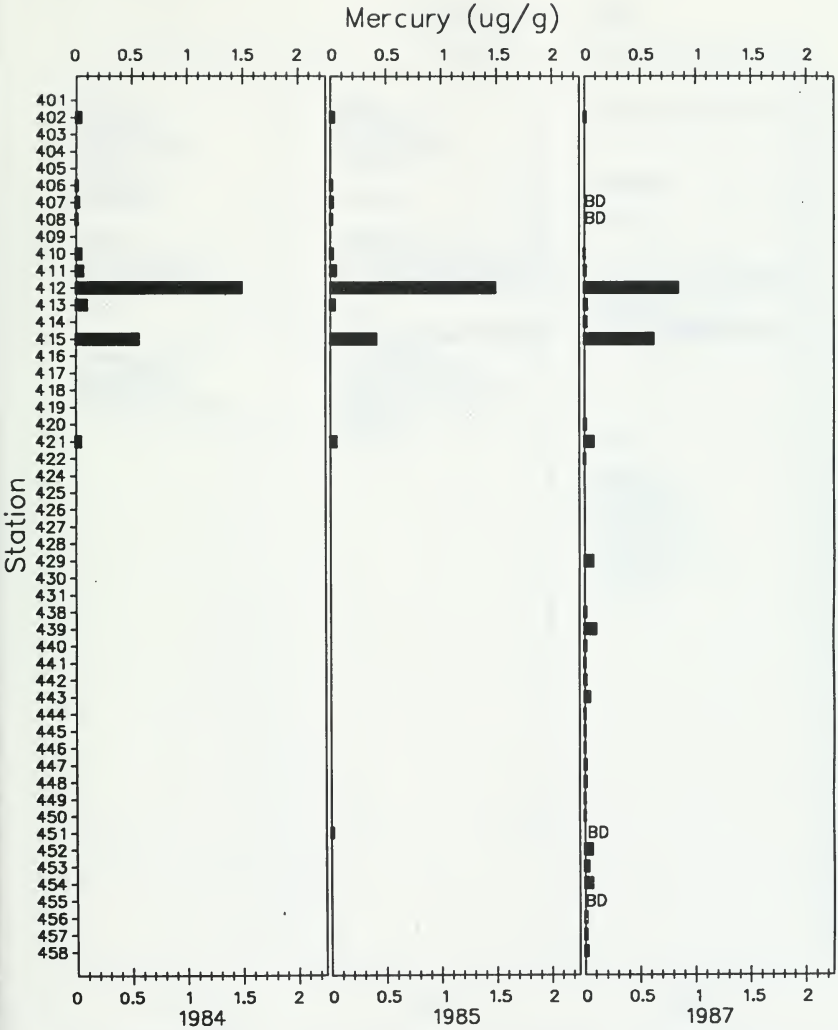


Figure Niag. 14.2: Elemental concentrations in Cladophora collected from the Niagara River.

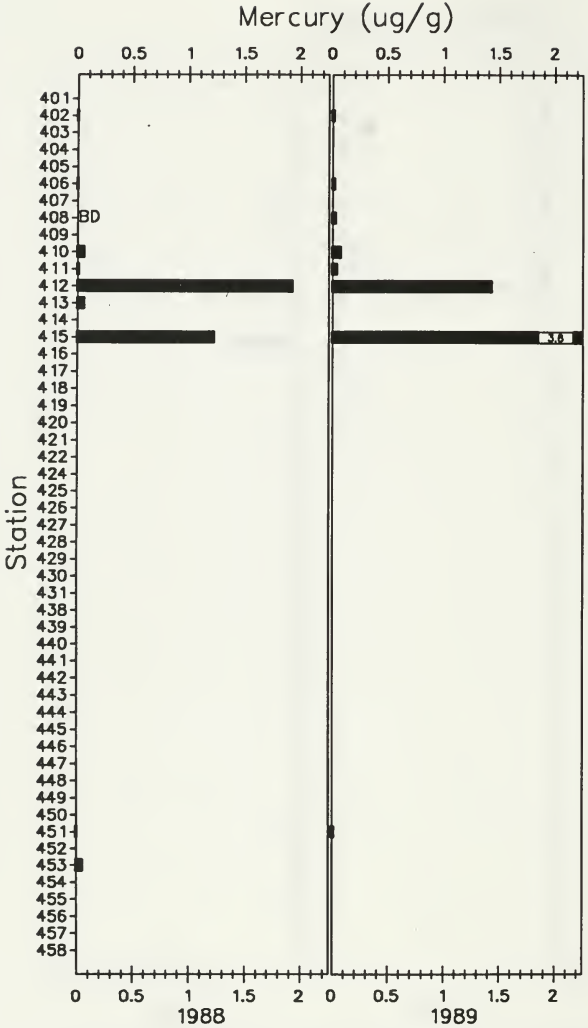


Figure Niag. 14.3: Elemental concentrations in Cladophora collected from the Niagara River.

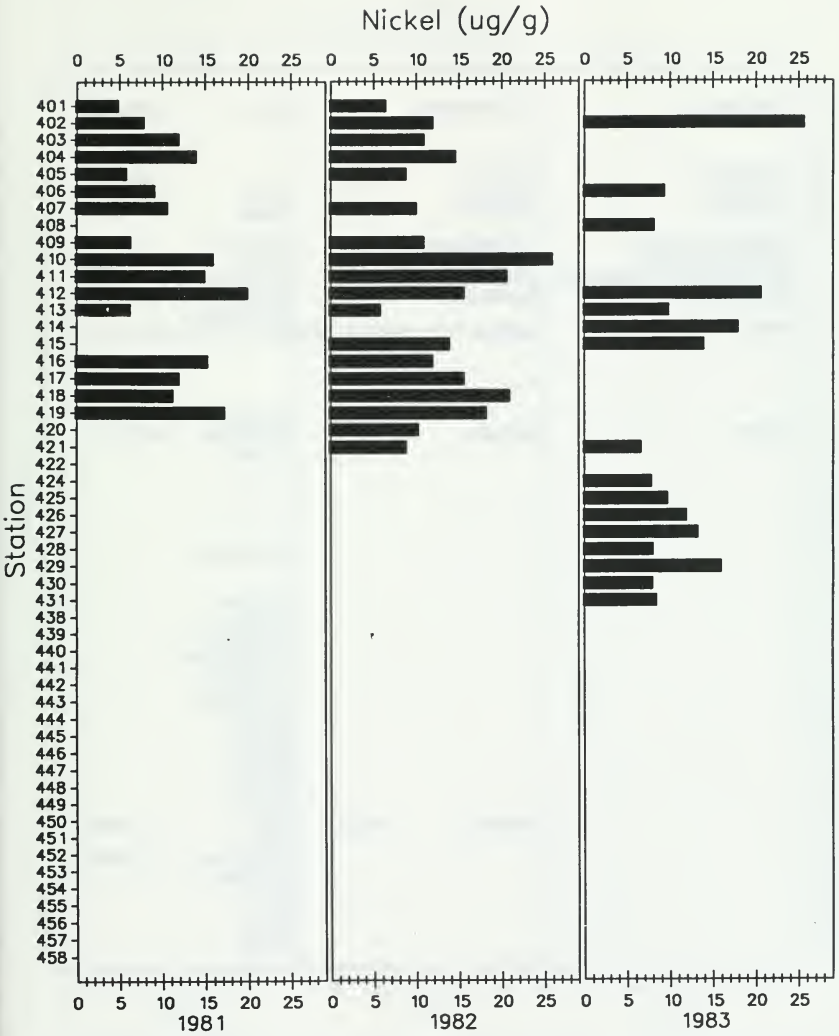


Figure Niag. 15. 1: Elemental concentrations in Cladophora collected from the Niagara River.

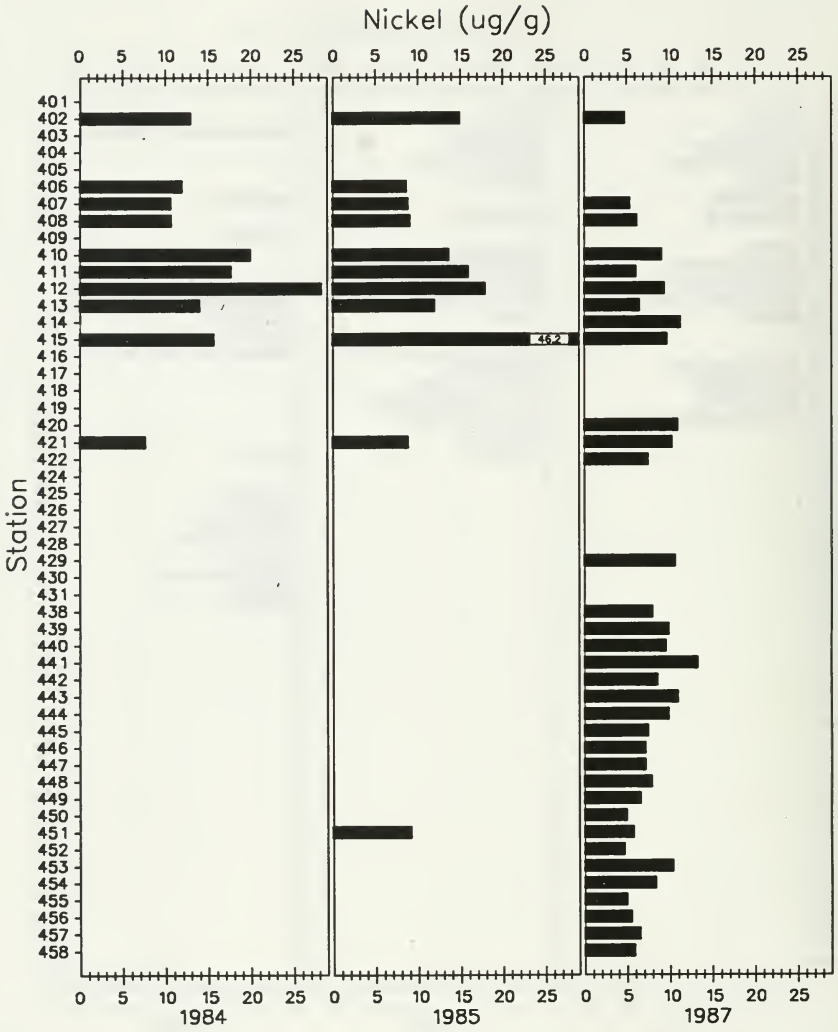


Figure Niag. 15.2: Elemental concentrations in Cladophora collected from the Niagara River.

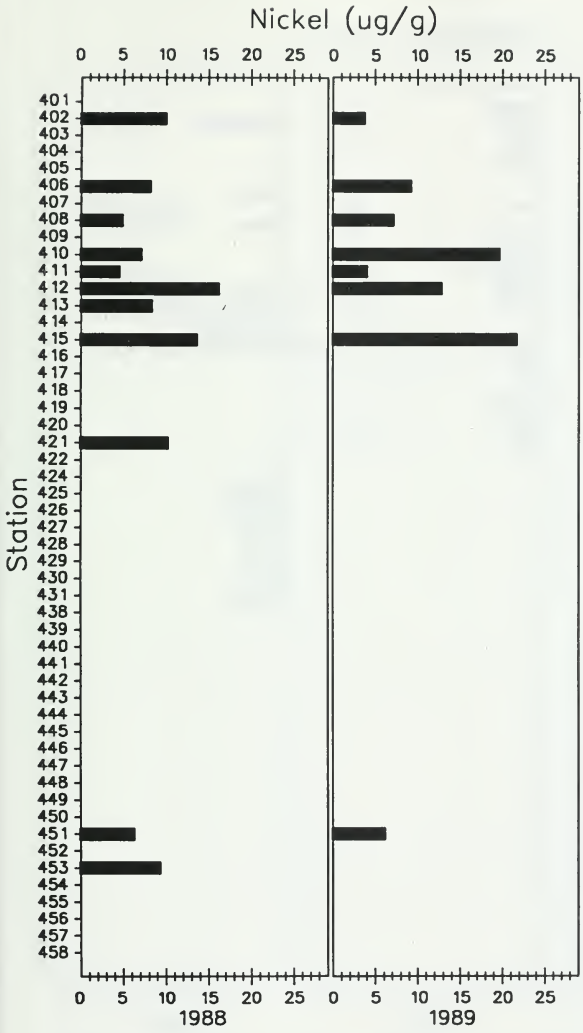


Figure Niag. 15.3: Elemental concentrations in Cladophora collected from the Niagara River.

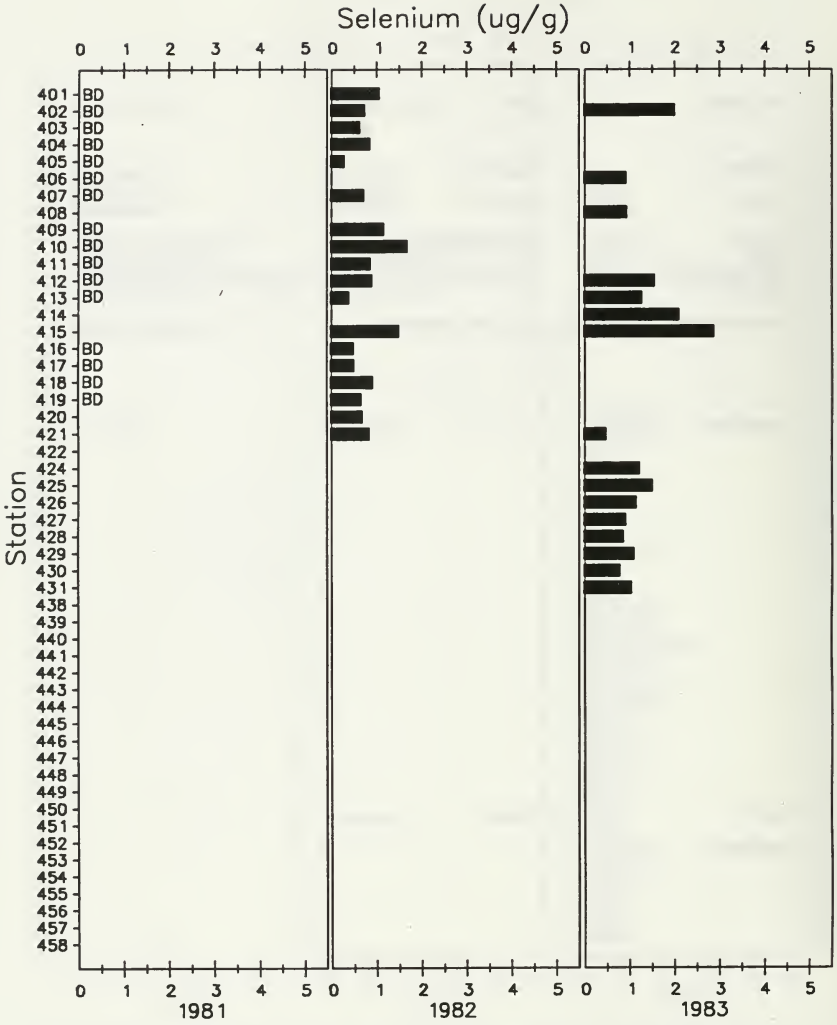


Figure Niag.16.1: Elemental concentrations in Cladophora collected from the Niagara River.

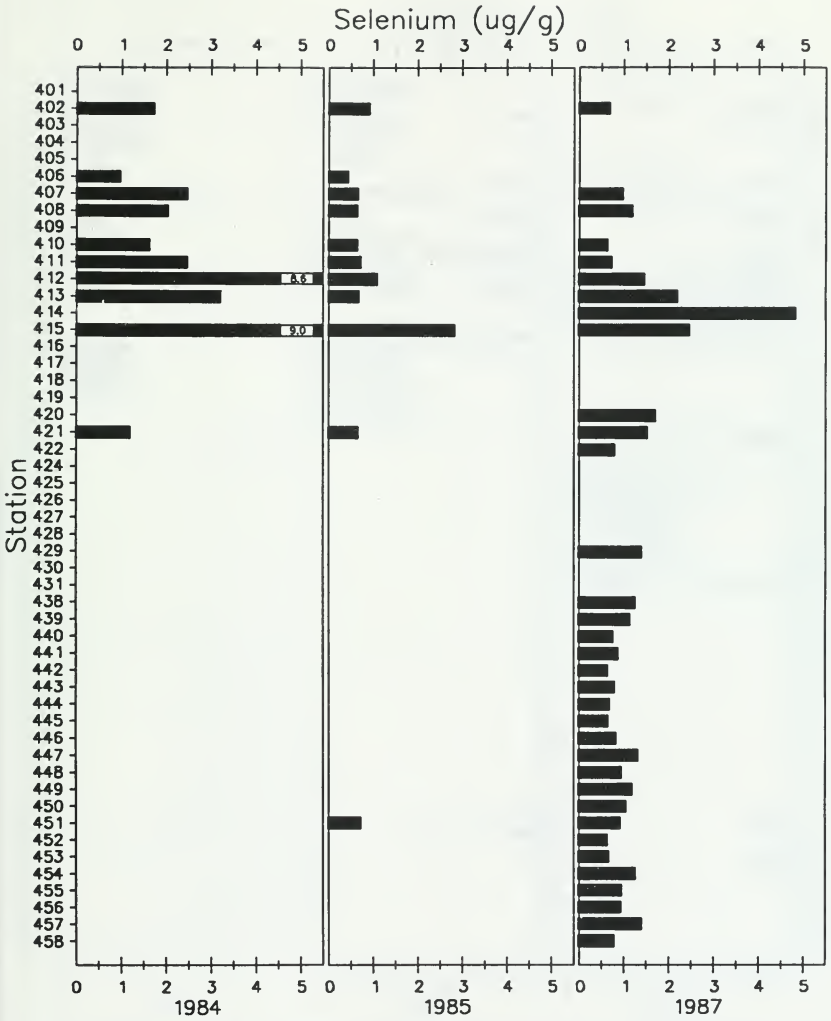


Figure Niag. 15.2: Elemental concentrations in Cladophora collected from the Niagara River.

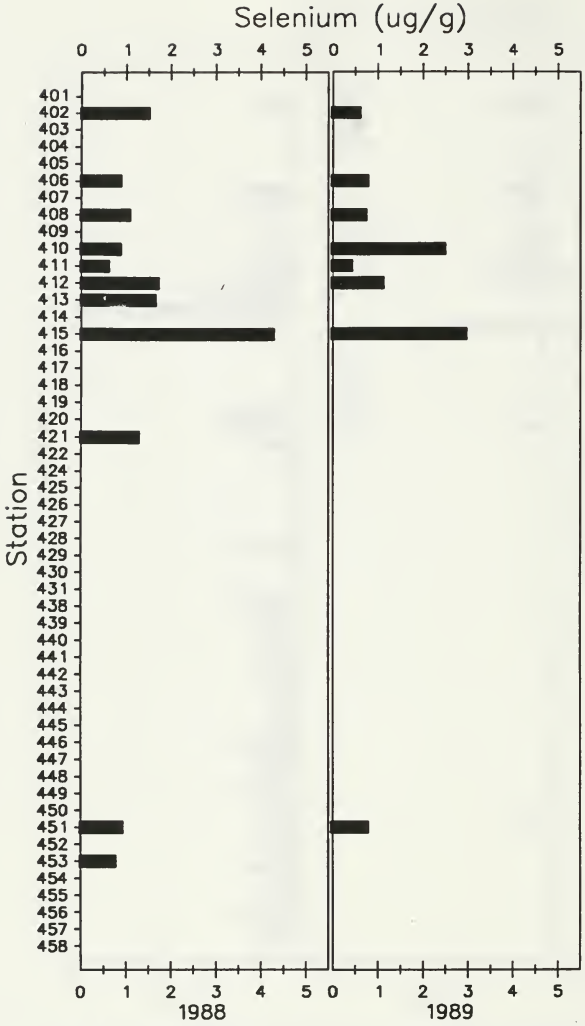


Figure Niag.16.3: Elemental concentrations in Cladophora collected from the Niagara River.

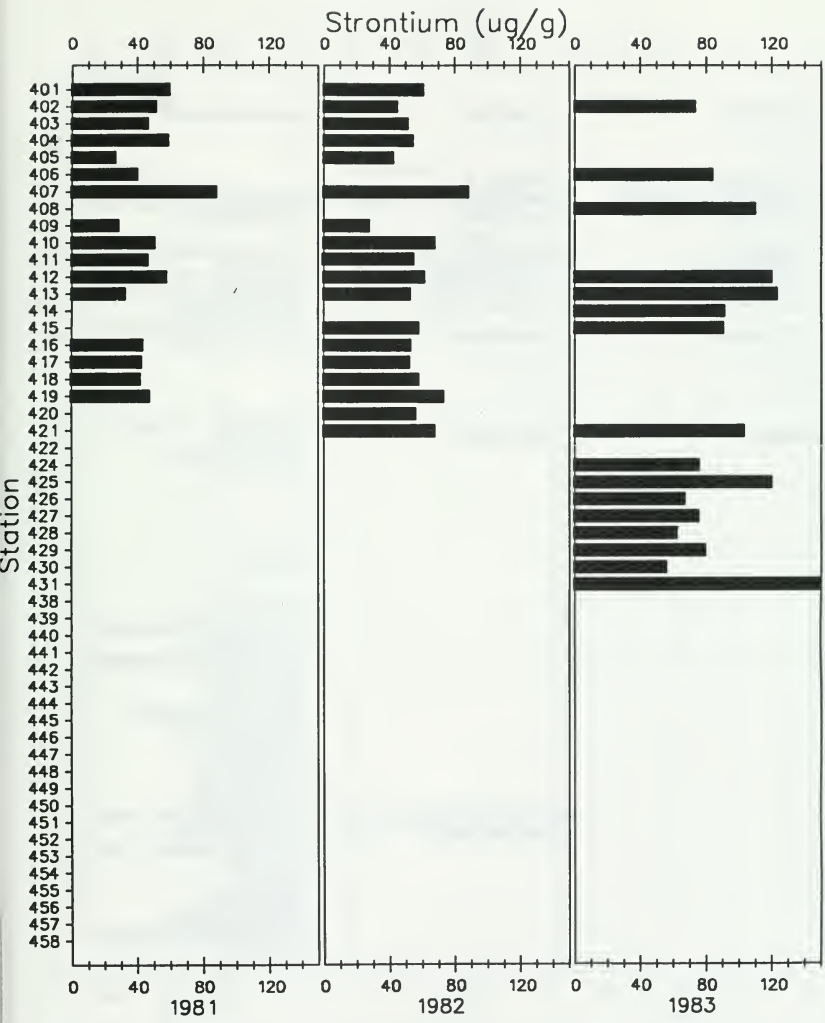


Figure Niag. 17. 1: Elemental concentrations in Cladophora collected from the Niagara River.

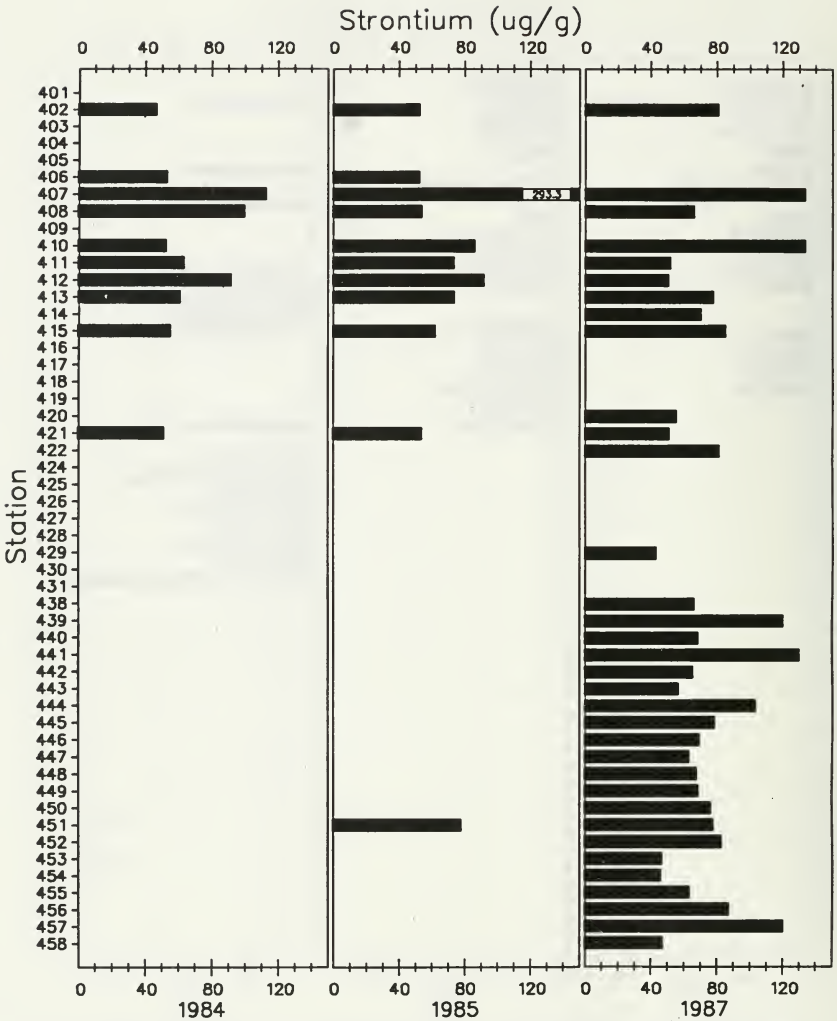


Figure Niag. 17.2: Elemental concentrations in Cladophora collected from the Niagara River.

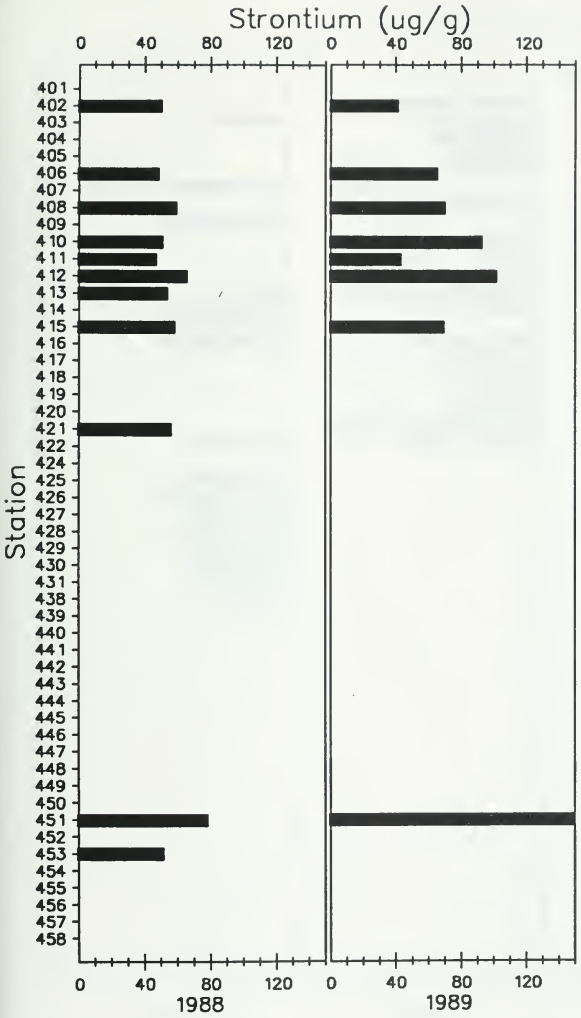


Figure Niag. 15.2: Elemental concentrations in Cladophora collected from the Niagara River.

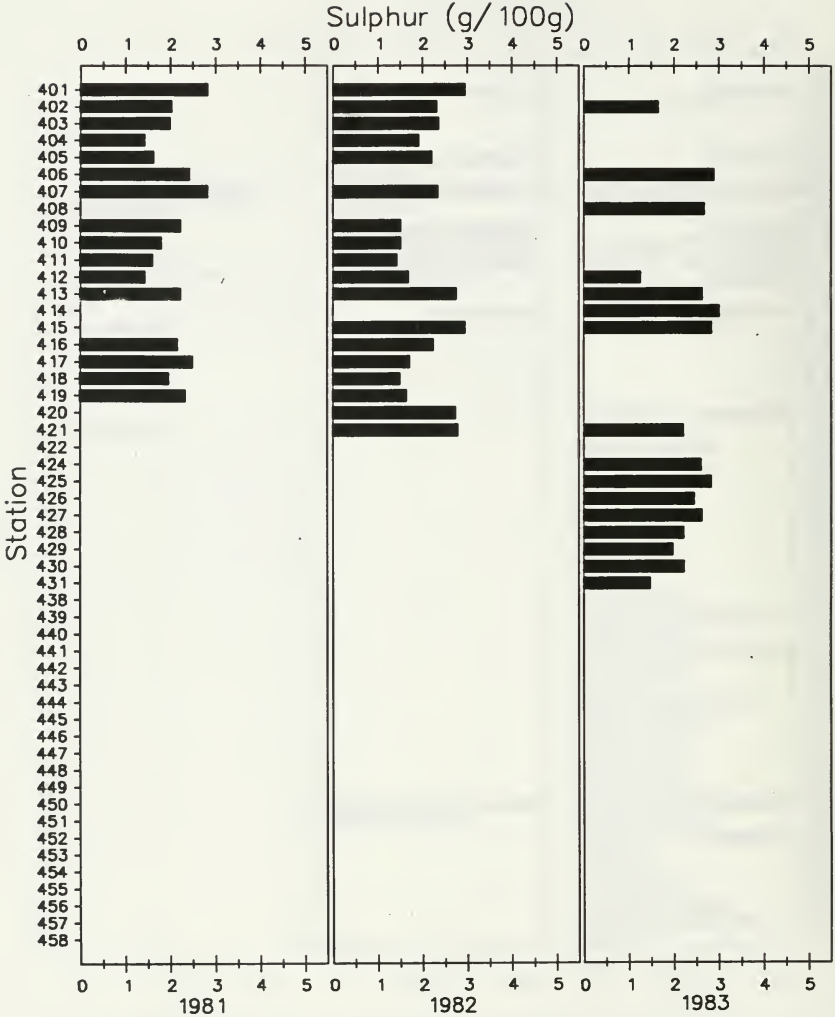


Figure Niag. 18. 1: Elemental concentrations in Cladophora collected from the Niagara River.

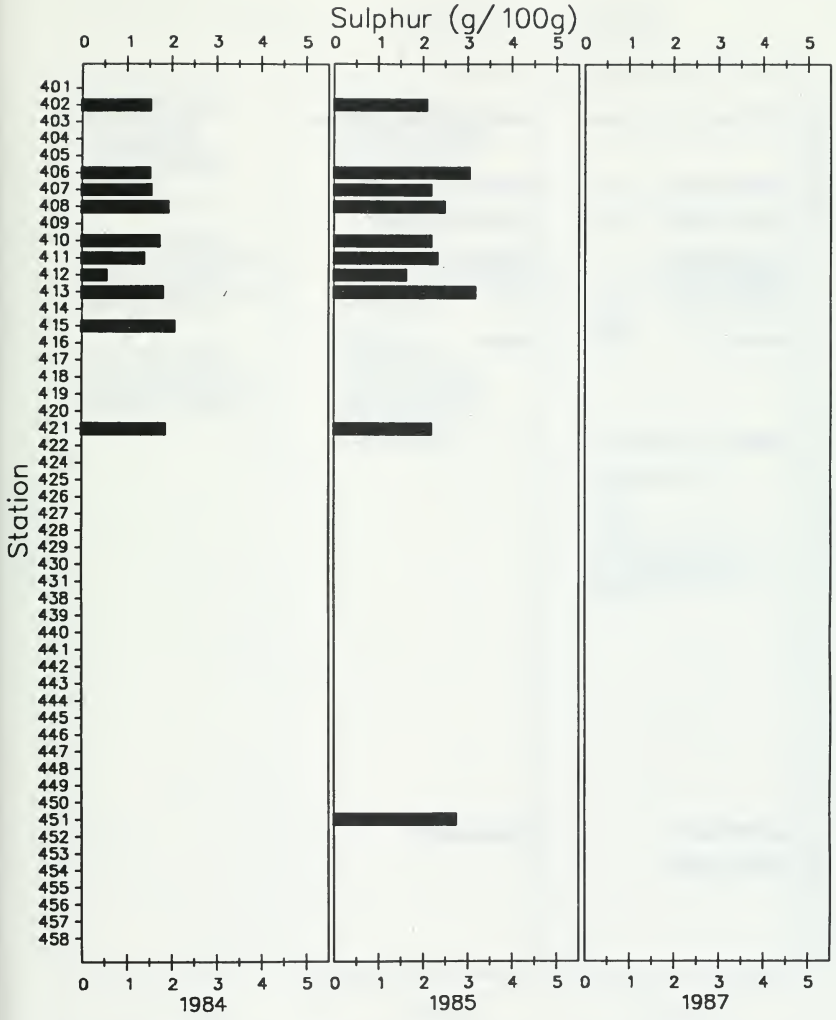


Figure Niag. 18.2: Elemental concentrations in Cladophora collected from the Niagara River.

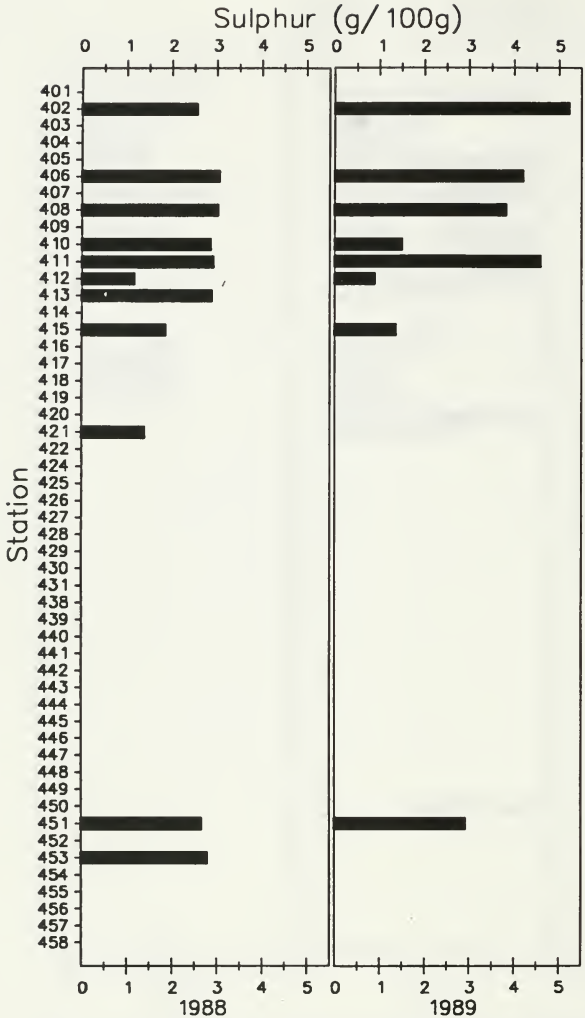


Figure Niag. 18.3: Elemental concentrations in Cladophora collected from the Niagara River.

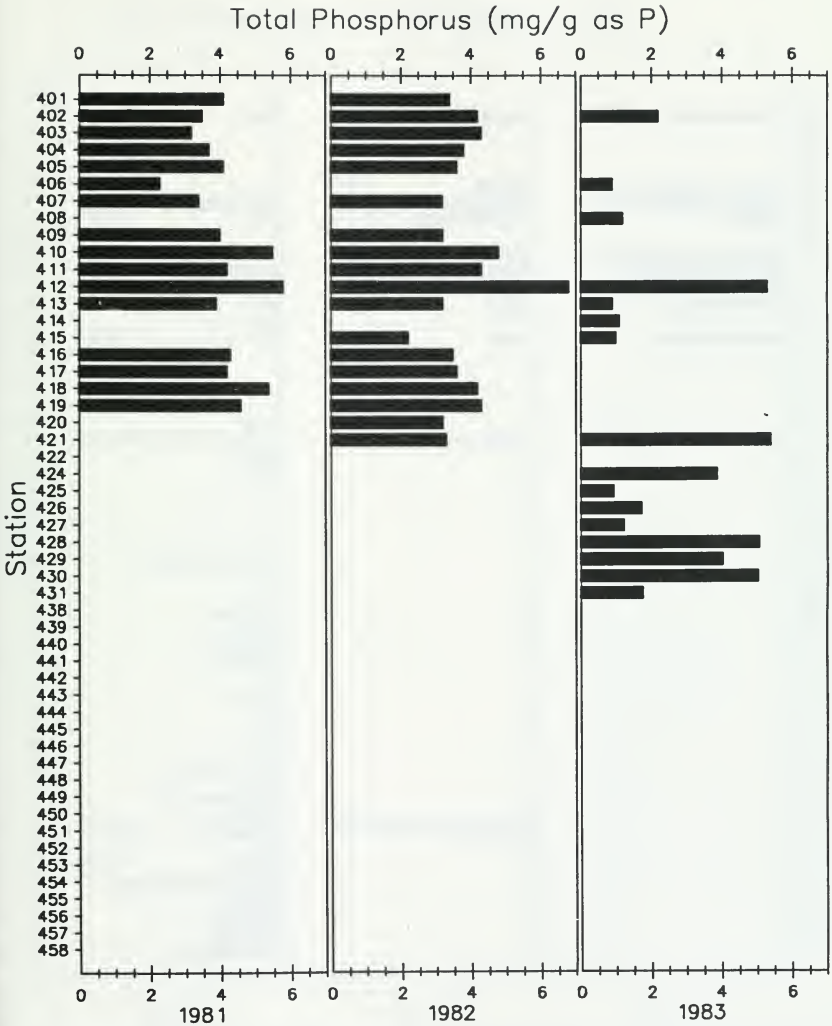


Figure Niag. 19. 1: Elemental concentrations in Cladophora collected from the Niagara River.

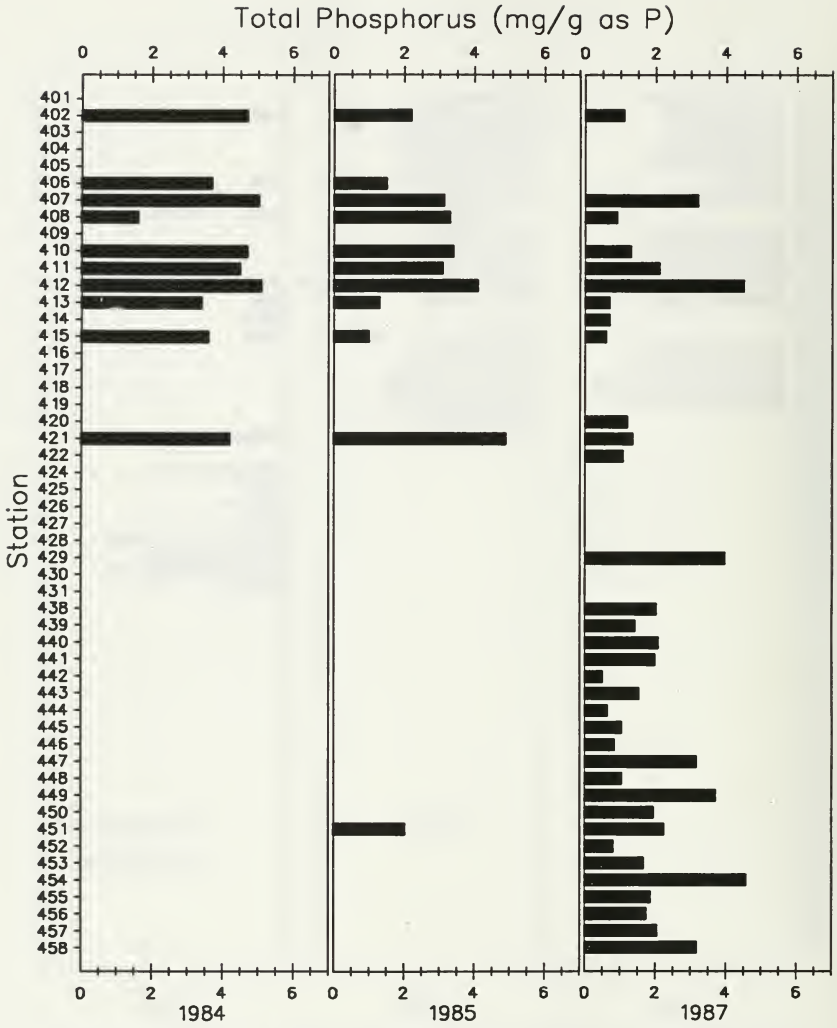


Figure Niag. 19.2: Elemental concentrations in Cladophora collected from the Niagara River.

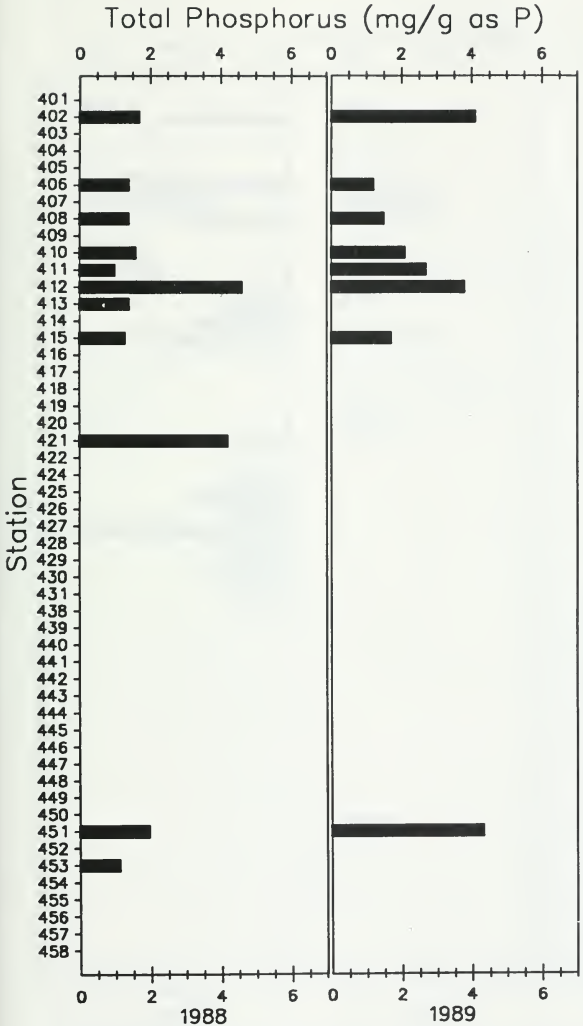


Figure Niag. 19.3: Elemental concentrations in Cladophora collected from the Niagara River.

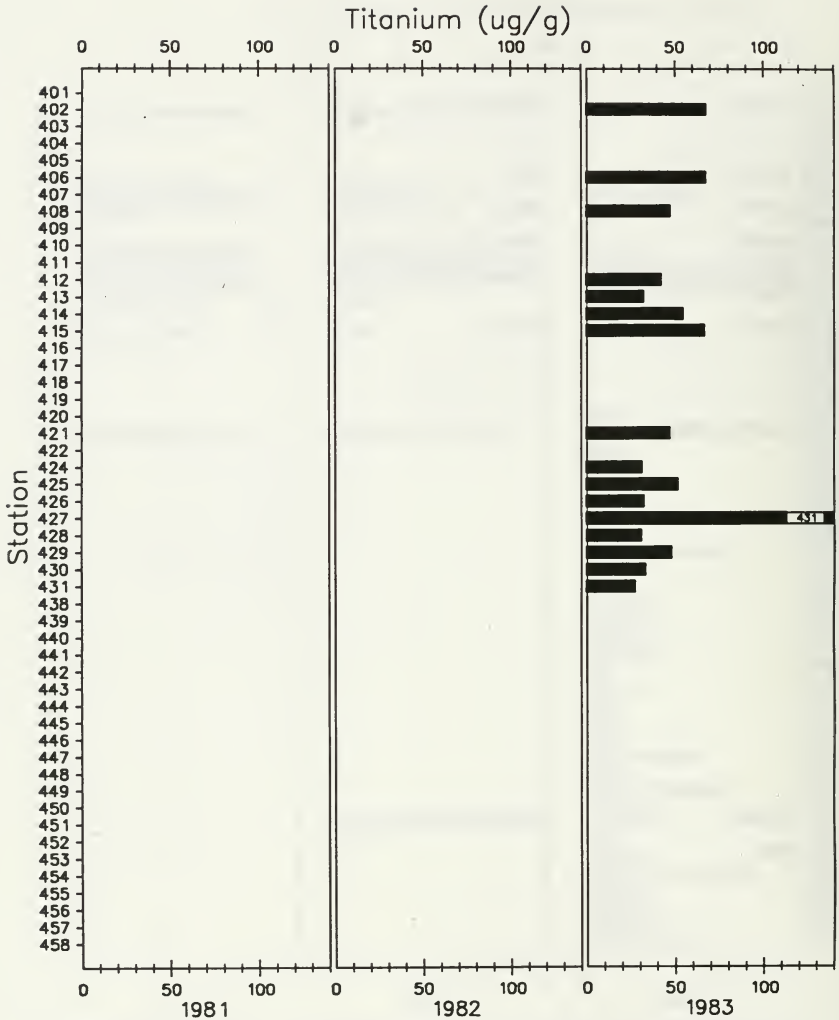


Figure Niag.20.1: Elemental concentrations in Cladophora collected from the Niagara River.

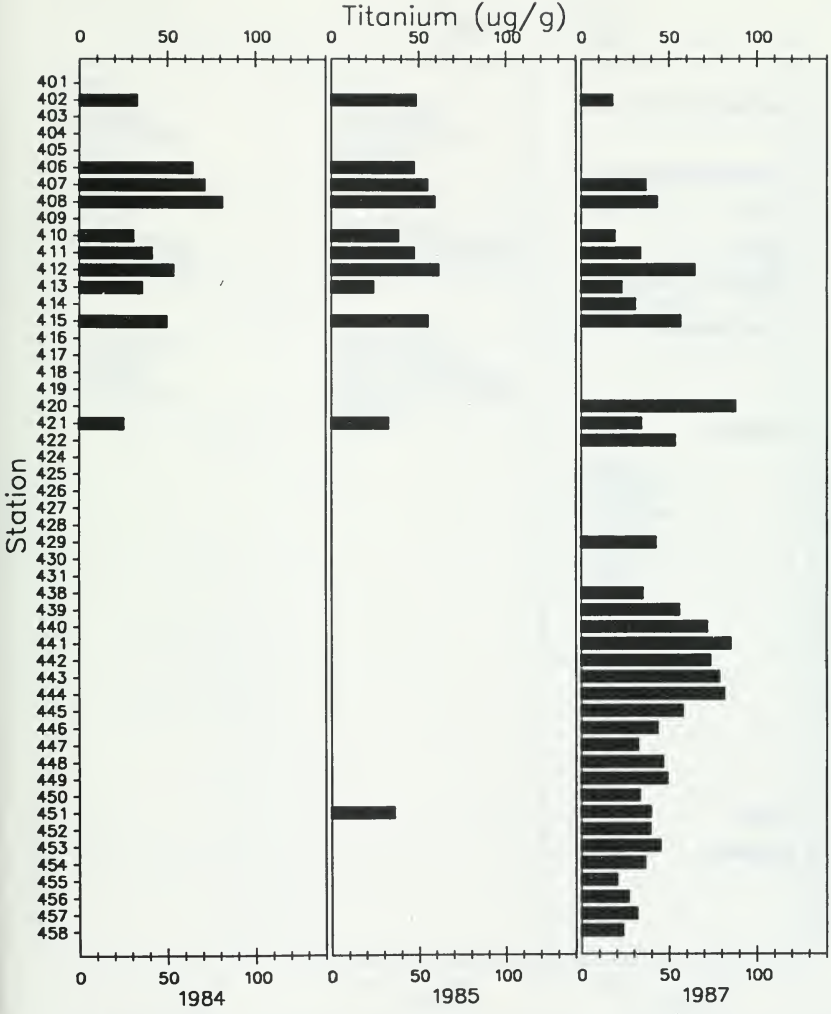


Figure Niag.20.2: Elemental concentrations in Cladophora collected from the Niagara River.

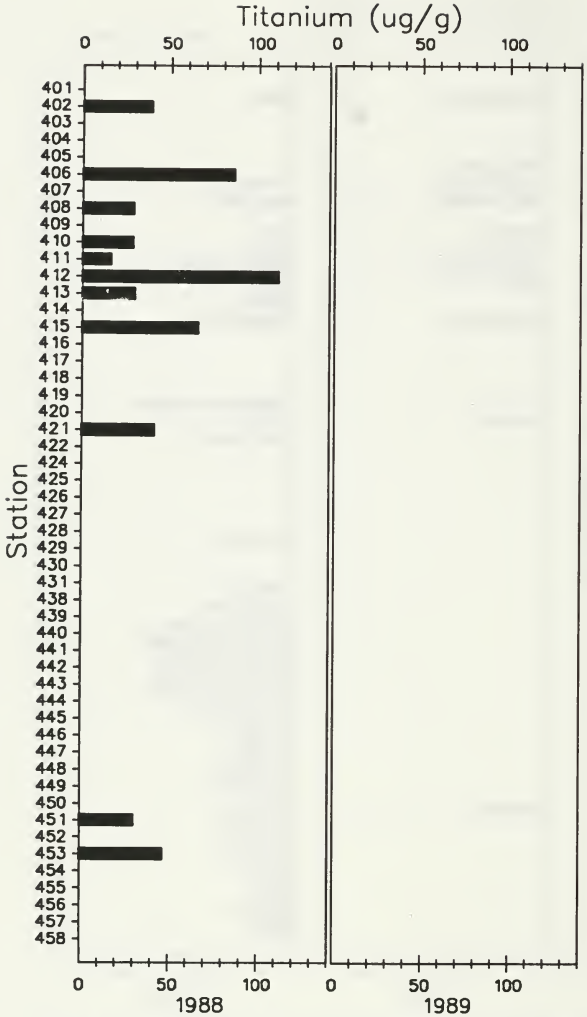


Figure Niag.20.3: Elemental concentrations in Cladophora collected from the Niagara River.

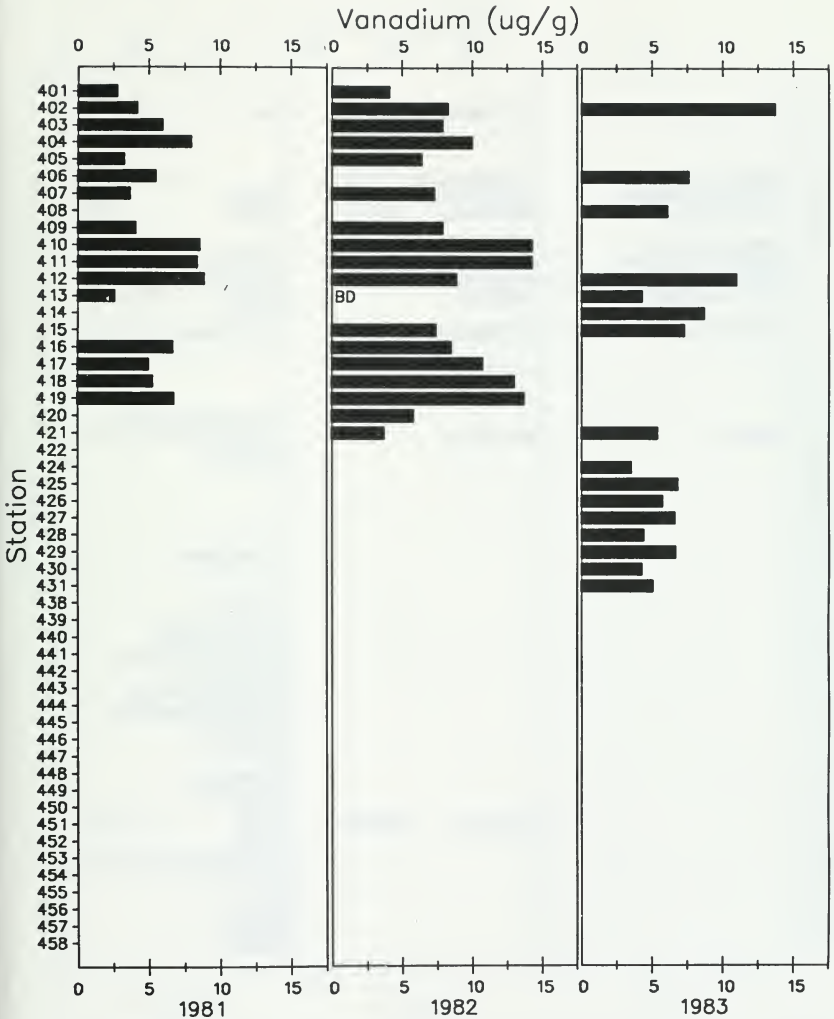


Figure Niag.21.1: Elemental concentrations in Cladophora collected from the Niagara River.

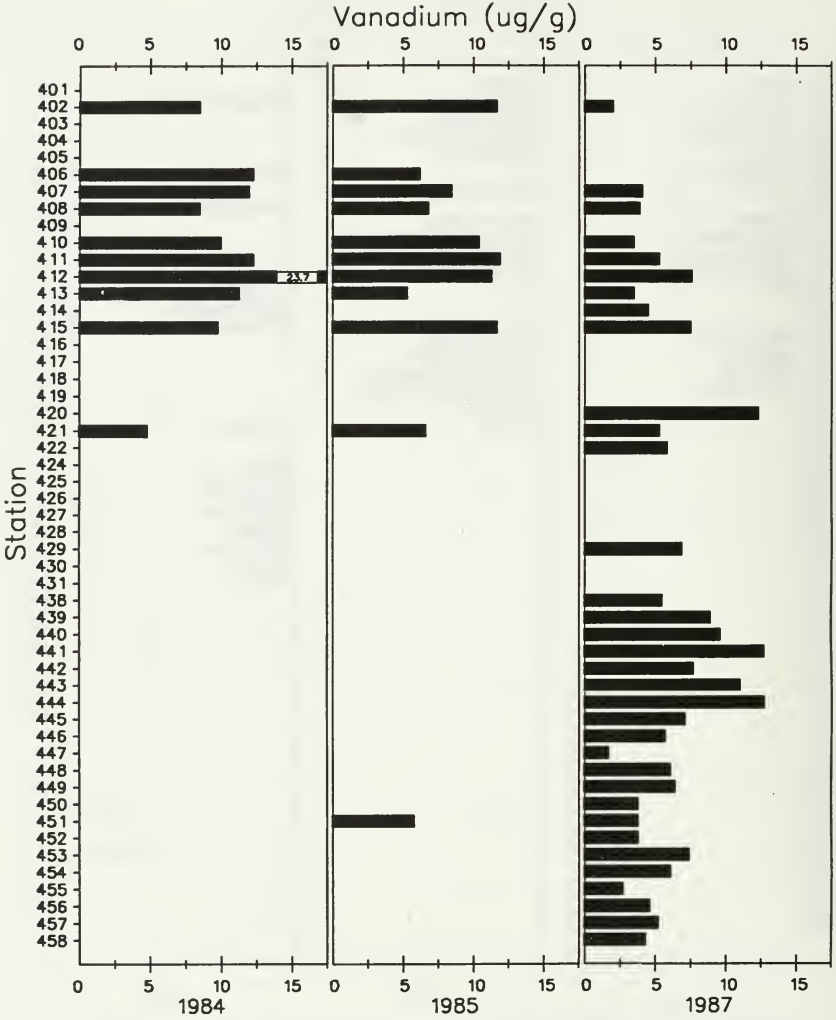


Figure Niag.21.2: Elemental concentrations in Cladophora collected from the Niagara River.

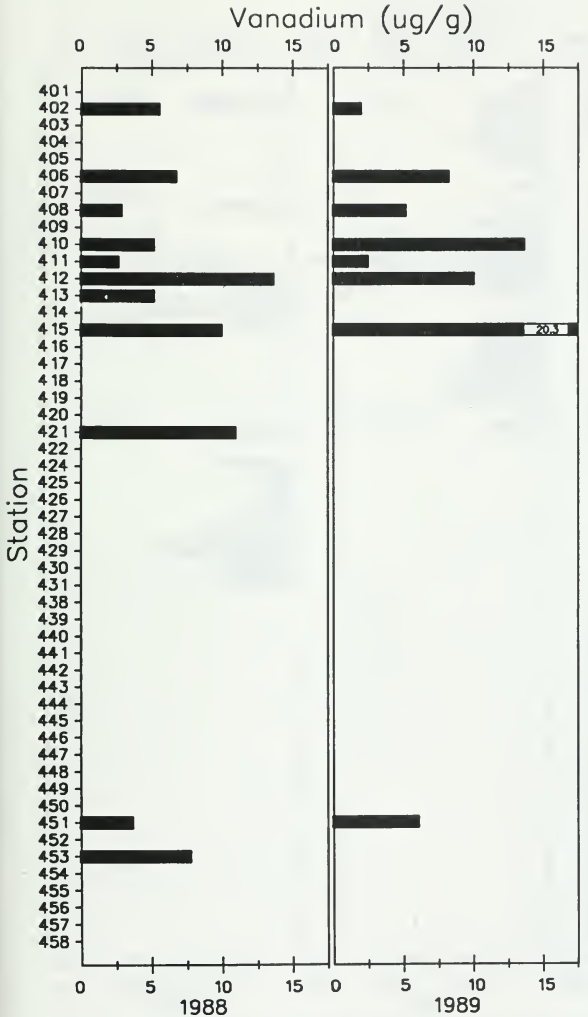


Figure Niag.21.3: Elemental concentrations in Cladophora collected from the Niagara River.

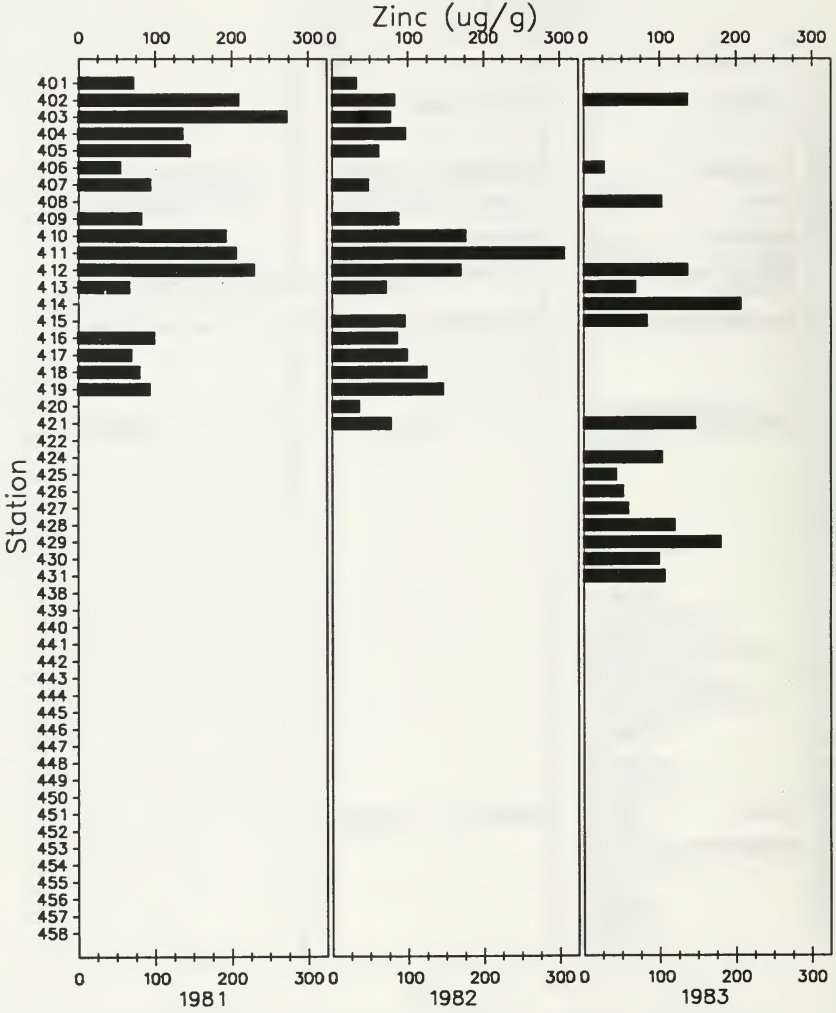


Figure Niag.22.1: Elemental concentrations in Cladophora collected from the Niagara River.

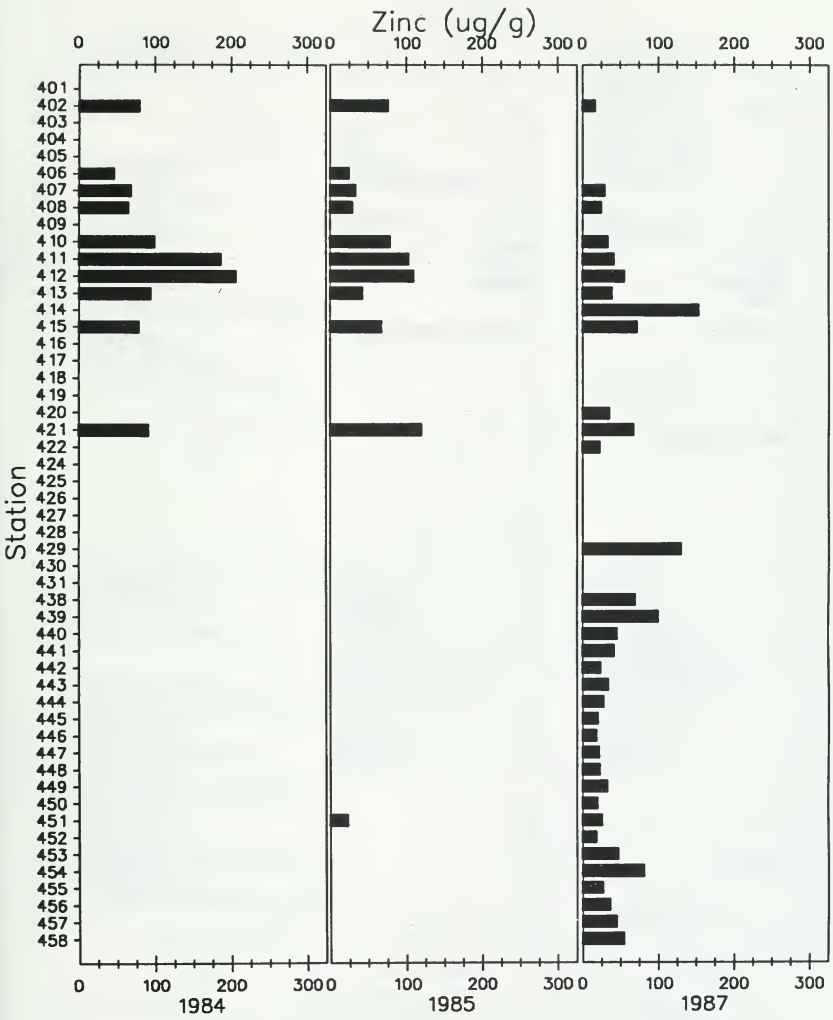


Figure Niag.22.2: Elemental concentrations in Cladophora collected from the Niagara River.

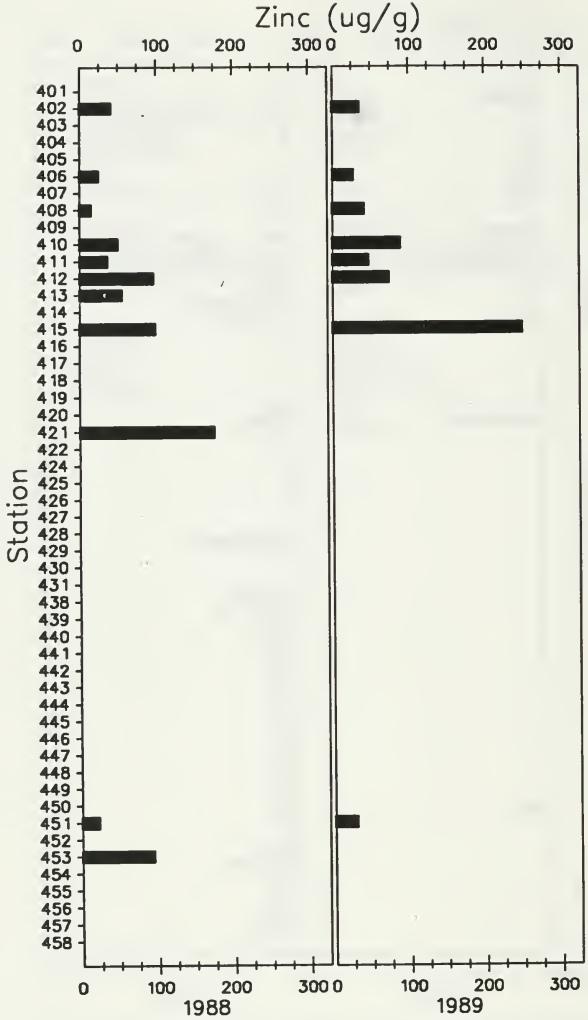
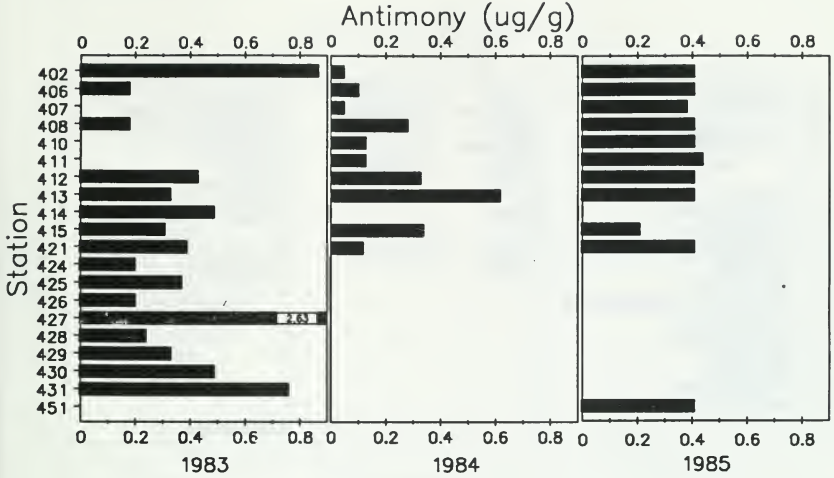


Figure Niag.22.3: Elemental concentrations in Cladophora collected from the Niagara River.



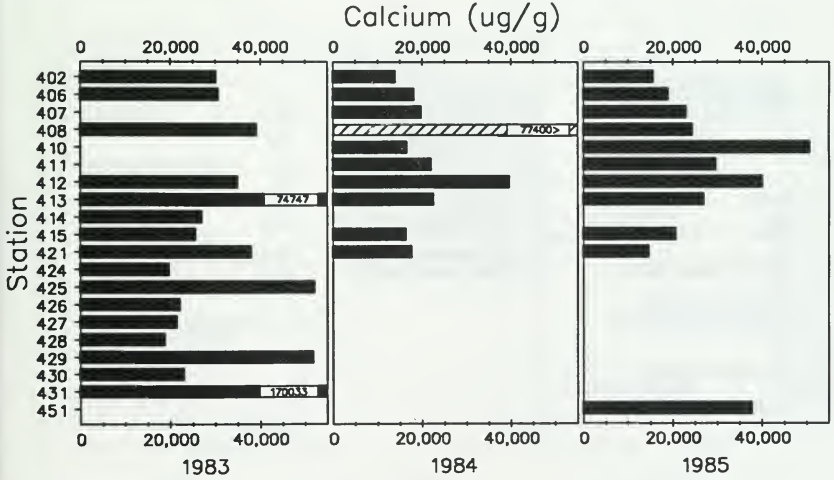


Figure Niag.23: Elemental concentrations in Cladophora collected from the Niagara River.
▨ Actual concentration of calcium was possibly greater than the value indicated.

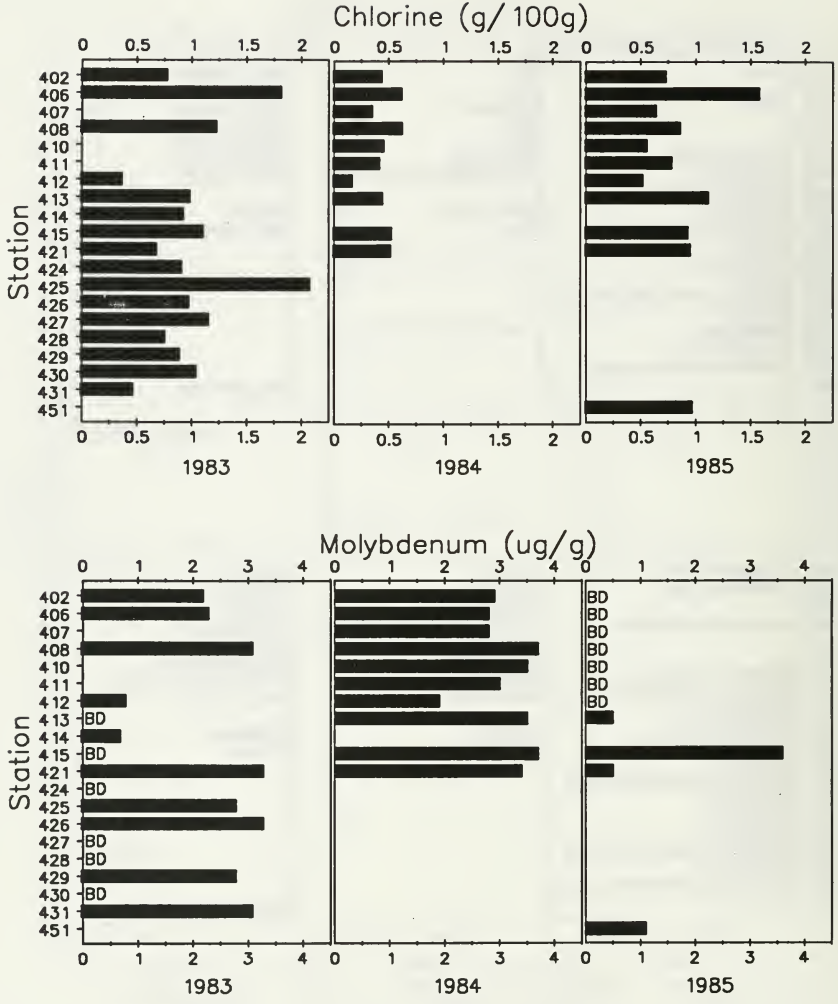


Figure Niag.24: Elemental concentrations in Cladophora collected from the Niagara River.

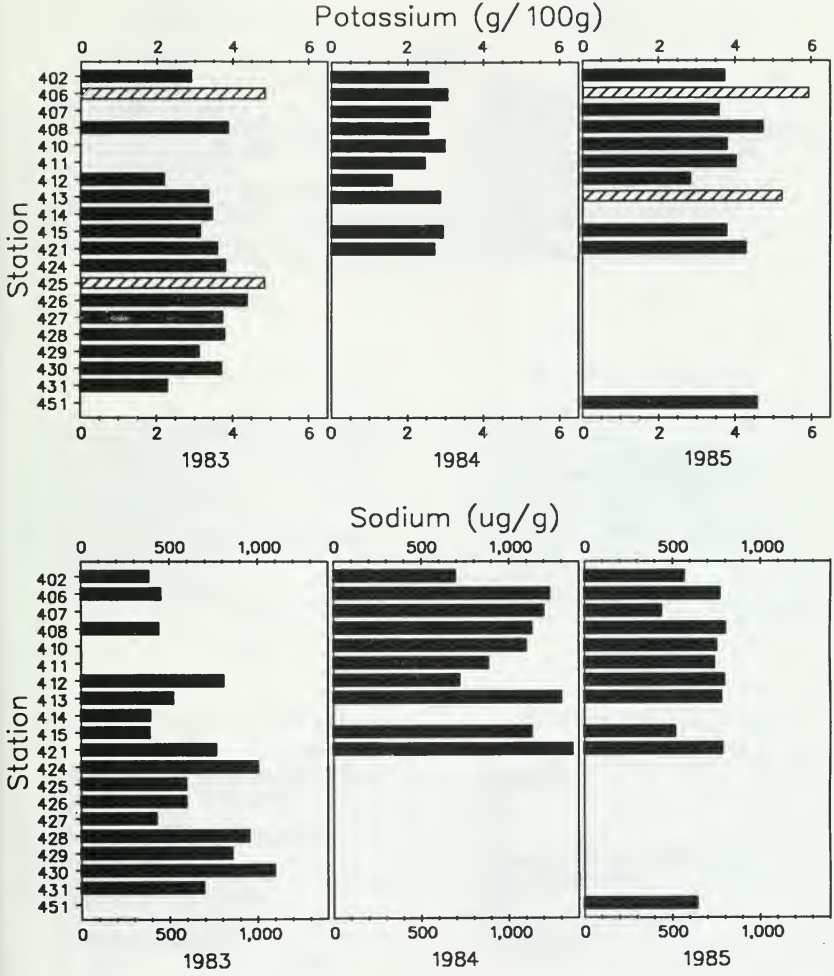


Figure Niag.25: Elemental concentrations in Cladophora collected from the Niagara River.
▨ Actual concentration of potassium was possibly greater than the value indicated.

IV. Lake Erie, 500 Series:

Elemental concentrations in *Cladophora* collected from Lake Erie at stations 501-503 and 505-510, for the year 1988.

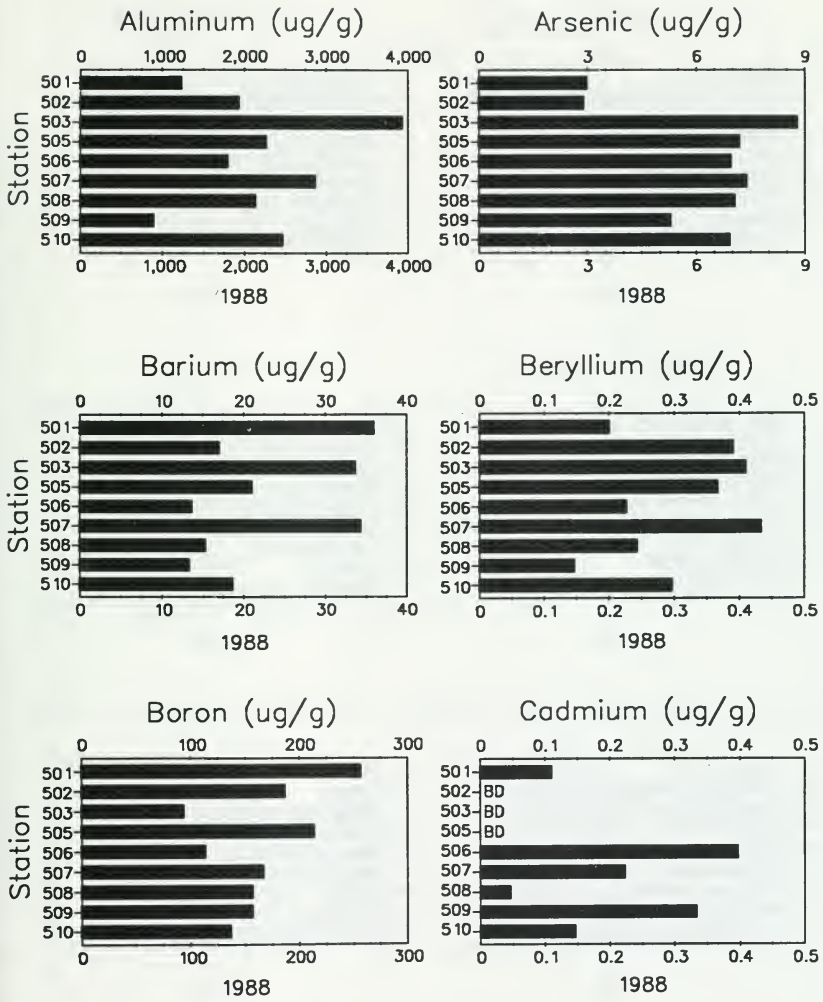


Figure Erie. 1: Elemental concentrations in Cladophora collected from Lake Erie.

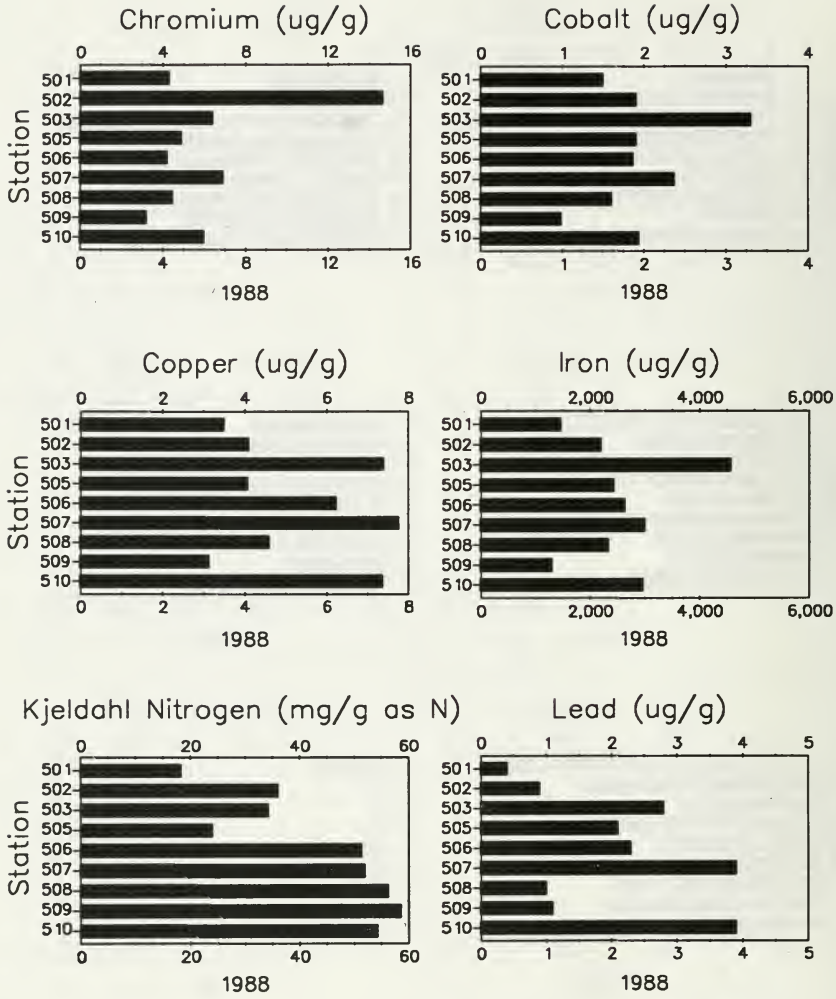


Figure Erie.2: Elemental concentrations in Cladophora collected from Lake Erie.

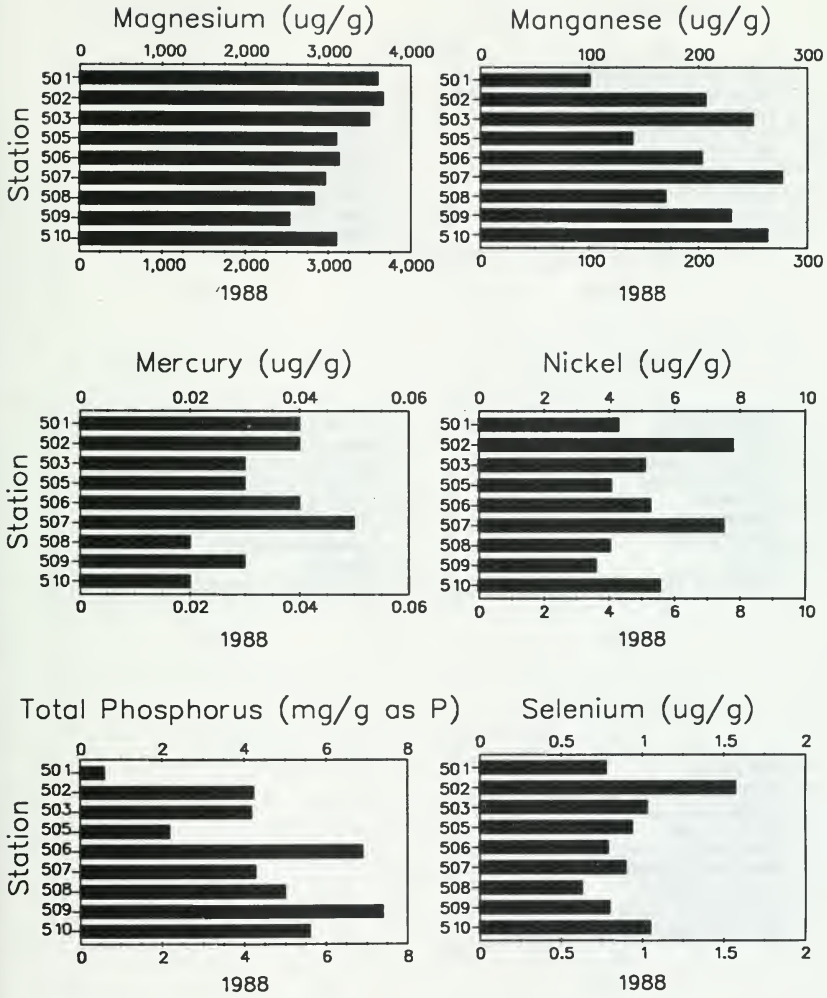


Figure Erie.3: Elemental concentrations in Cladophora collected from Lake Erie.

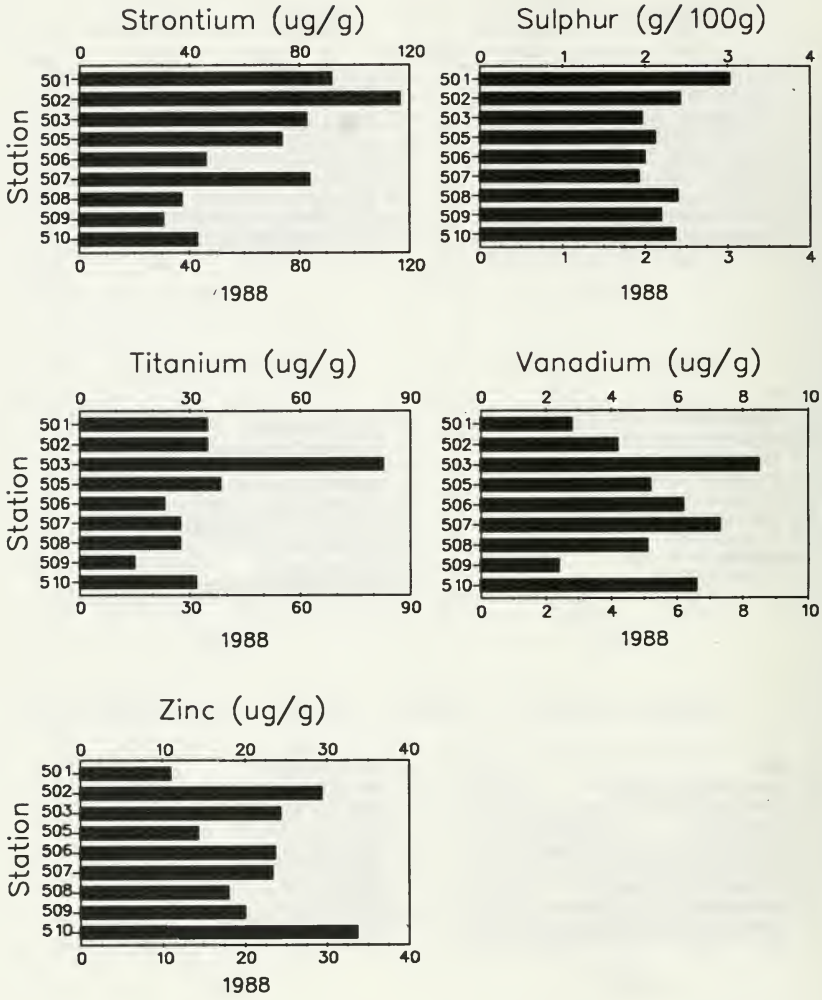


Figure Erie.4: Elemental concentrations in Cladophora collected from Lake Erie.

V. Detroit River 600 Series:

Elemental concentrations in *Cladophora* collected from Detroit River at stations 601, 602 and 603, for the years 1986-1988.

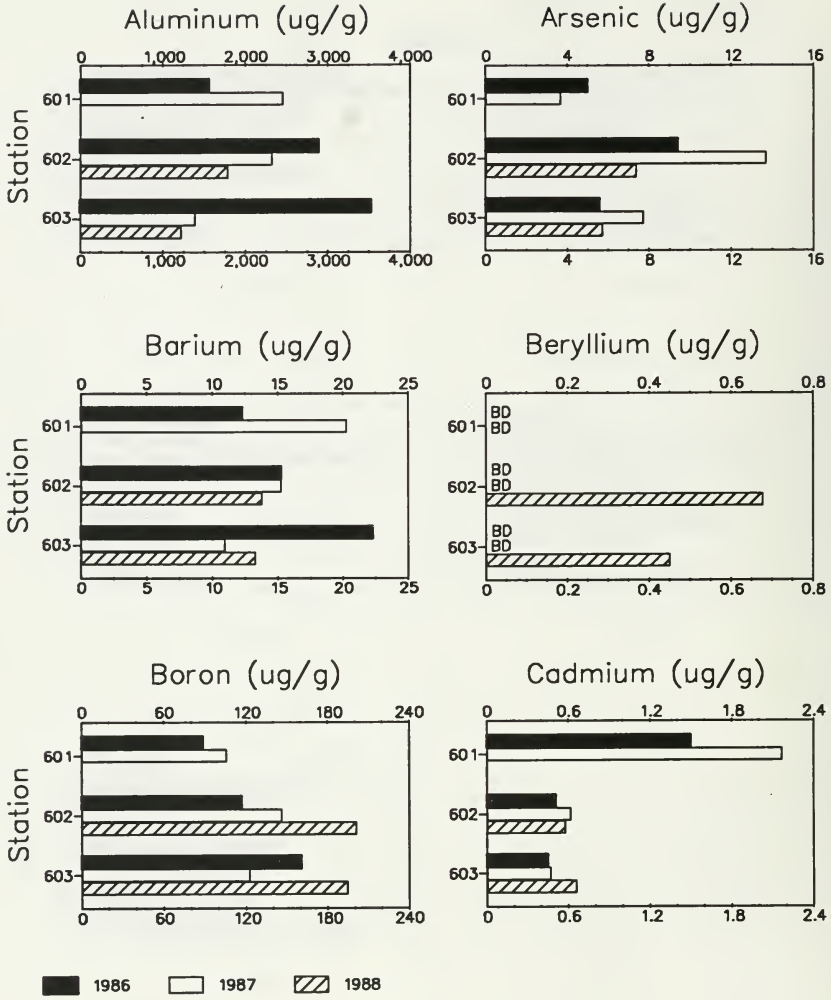


Figure Det. 1: Elemental concentrations in Cladophora collected from the Detroit River.

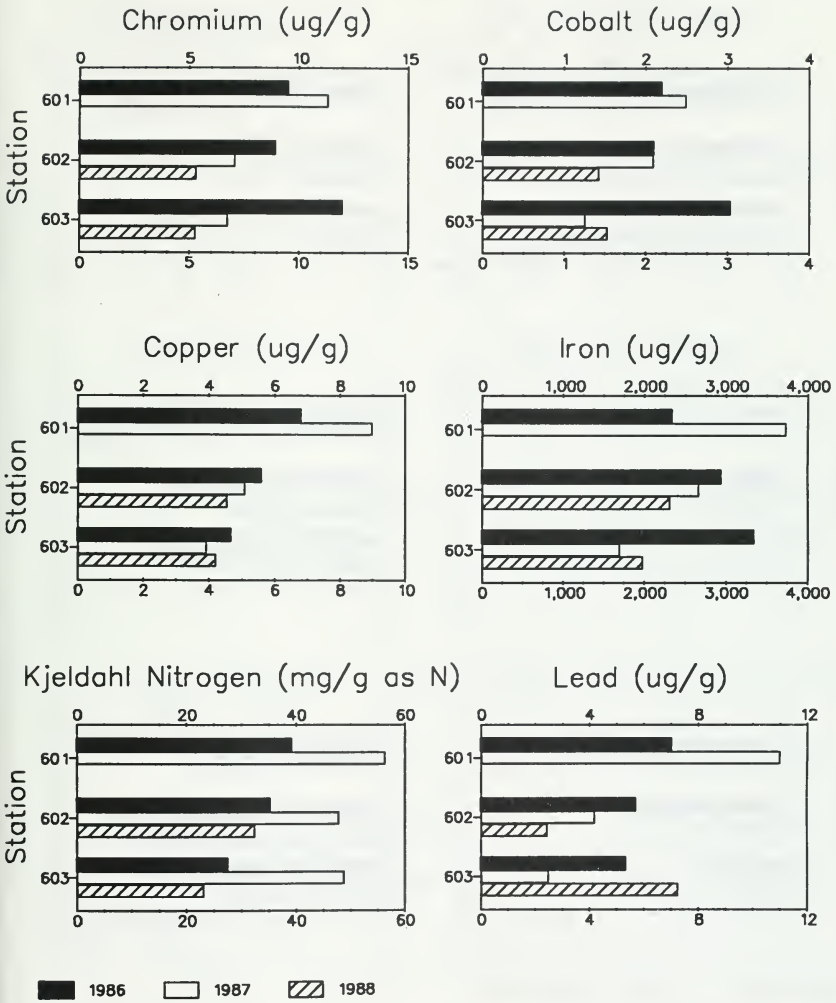


Figure Det.2: Elemental concentrations in Cladophora collected from the Detroit River.

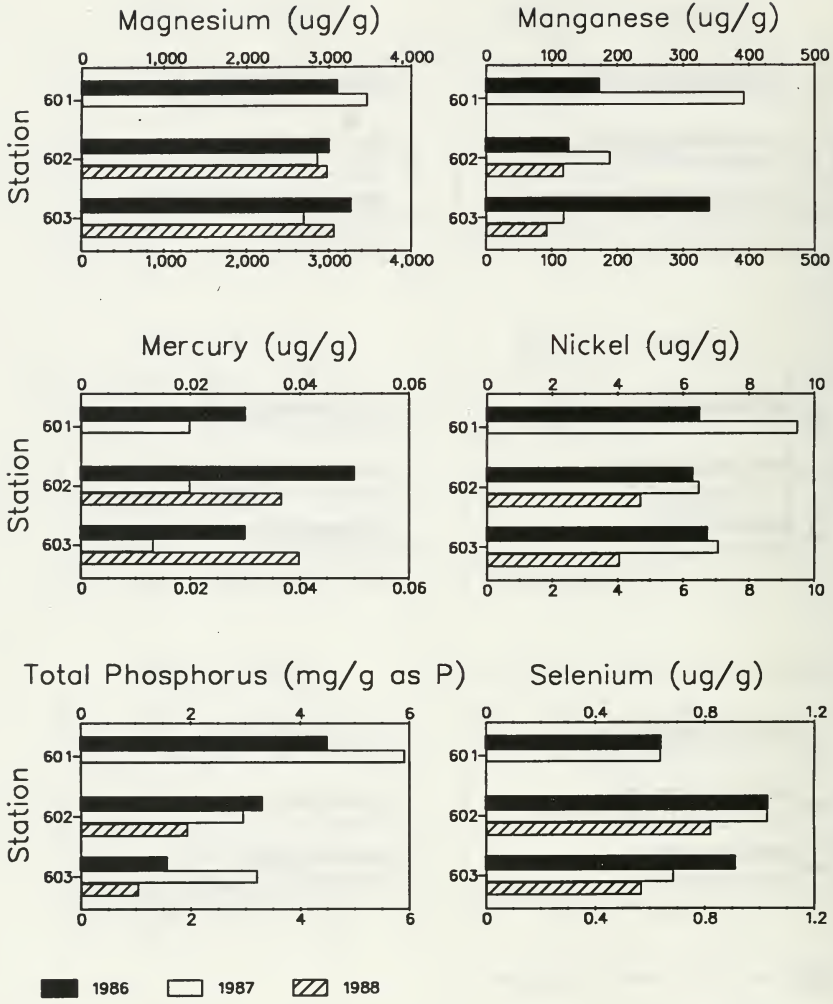


Figure Det.3: Elemental concentrations in Cladophora collected from the Detroit River.

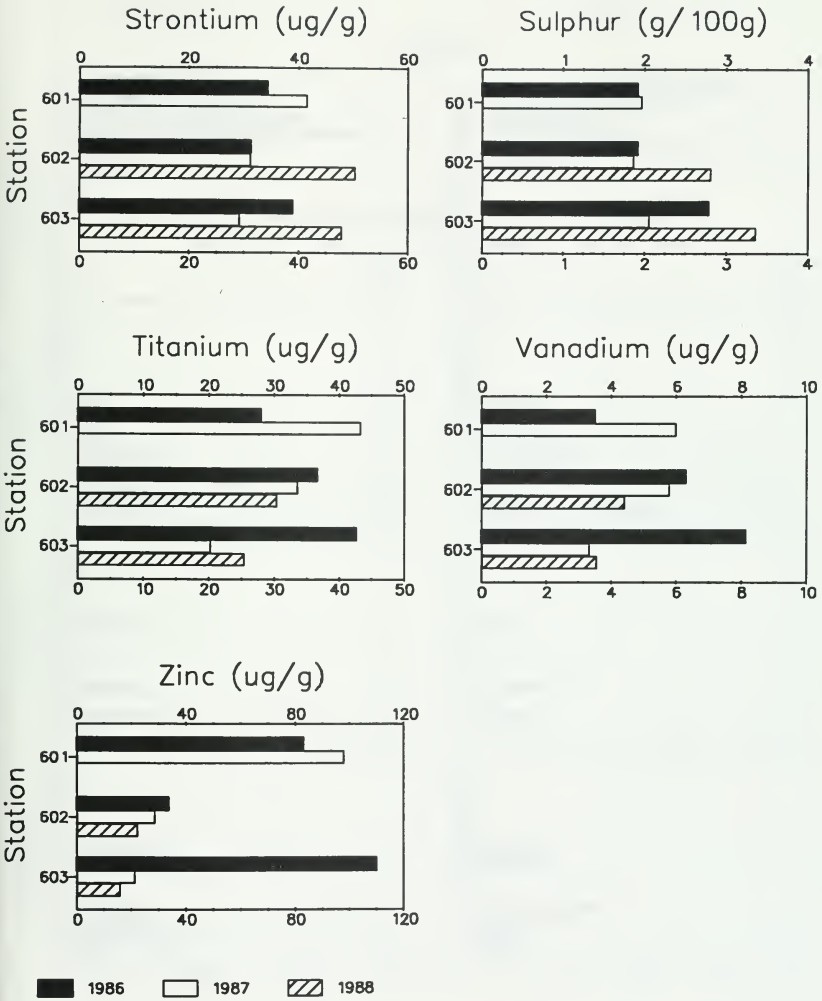


Figure Det.4: Elemental concentrations in Cladophora collected from the Detroit River.

VI. St. Clair River, 700 Series:

Elemental concentrations in *Cladophora* collected from St. Clair River at stations 701-706 and 708-716, for the years 1984 and 1986-1988.

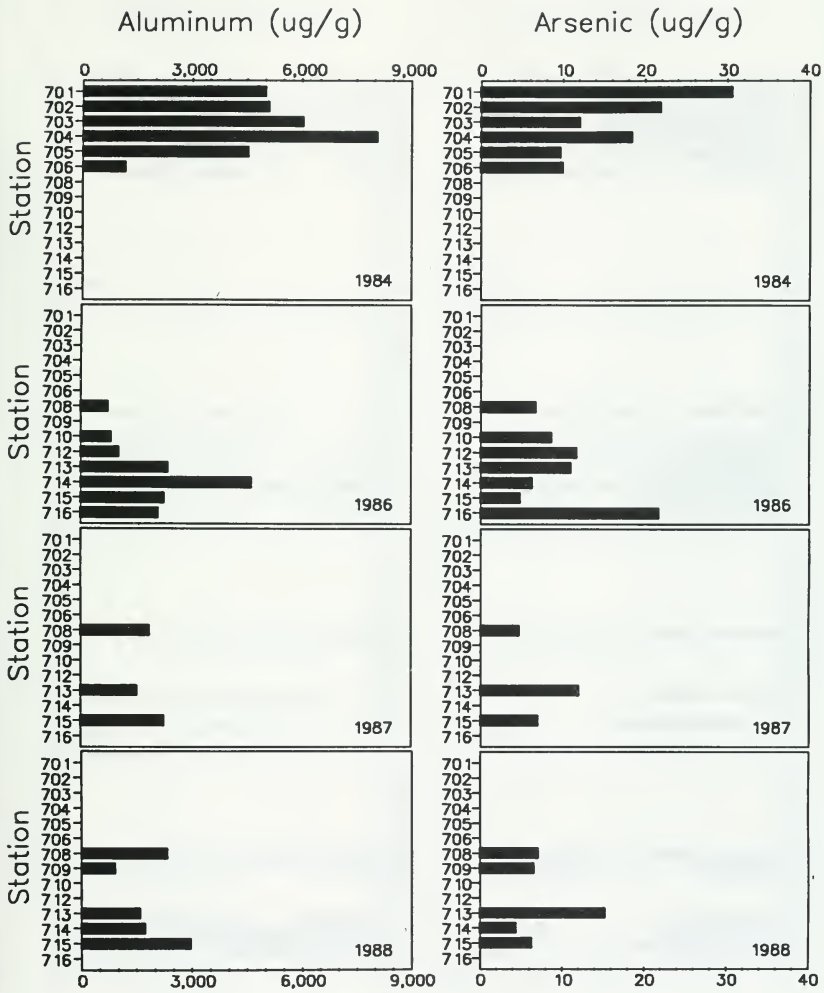


Figure SCR.1: Elemental concentrations in Cladophora collected from the St. Clair River.

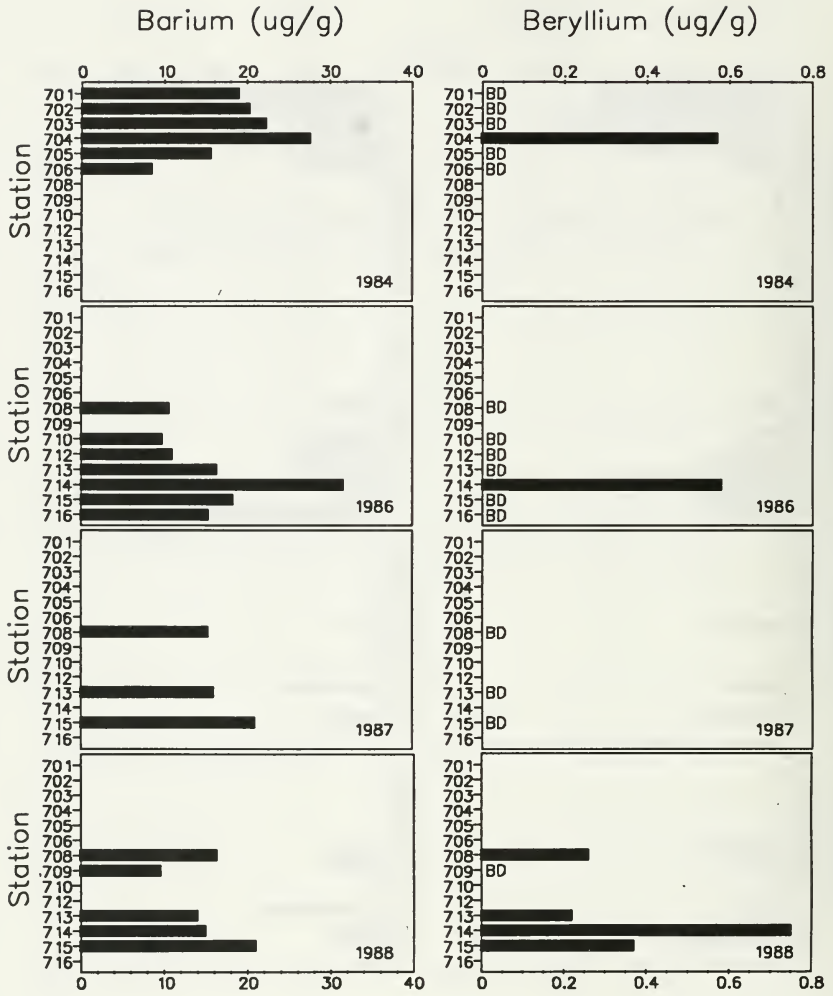


Figure SCR.2: Elemental concentrations in Cladophora collected from the St. Clair River.

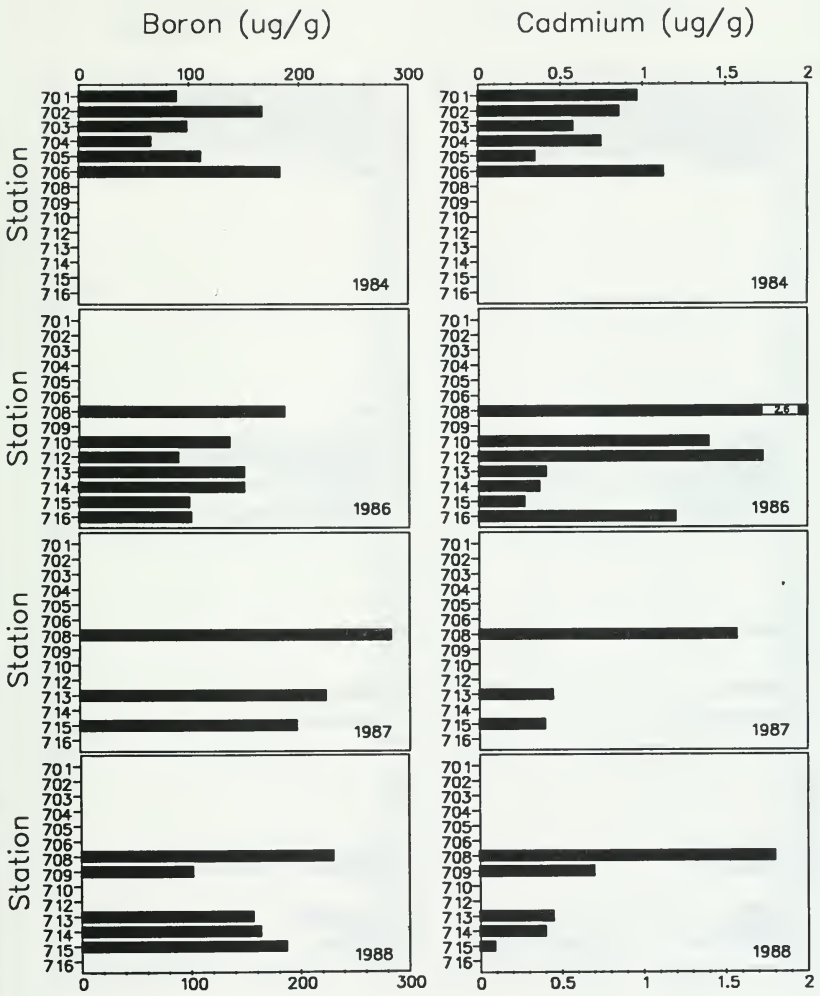


Figure SCR.3: Elemental concentrations in Cladophora collected from the St. Clair River.

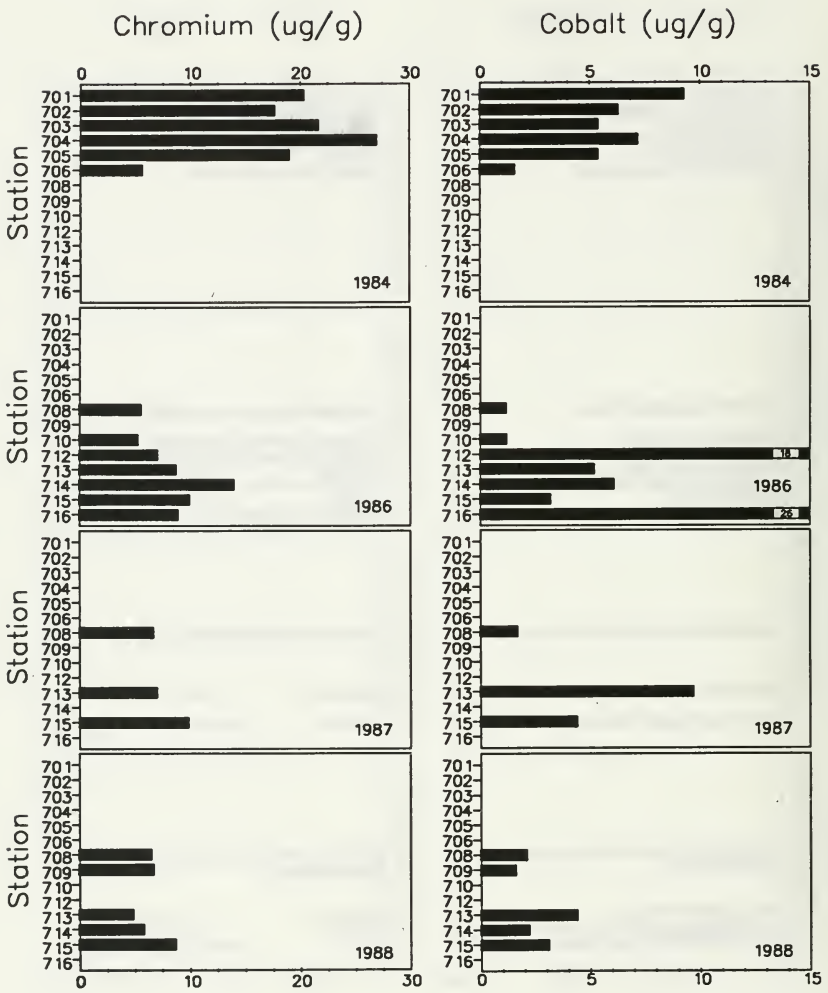


Figure SCR.4: Elemental concentrations in Cladophora collected from the St. Clair River.

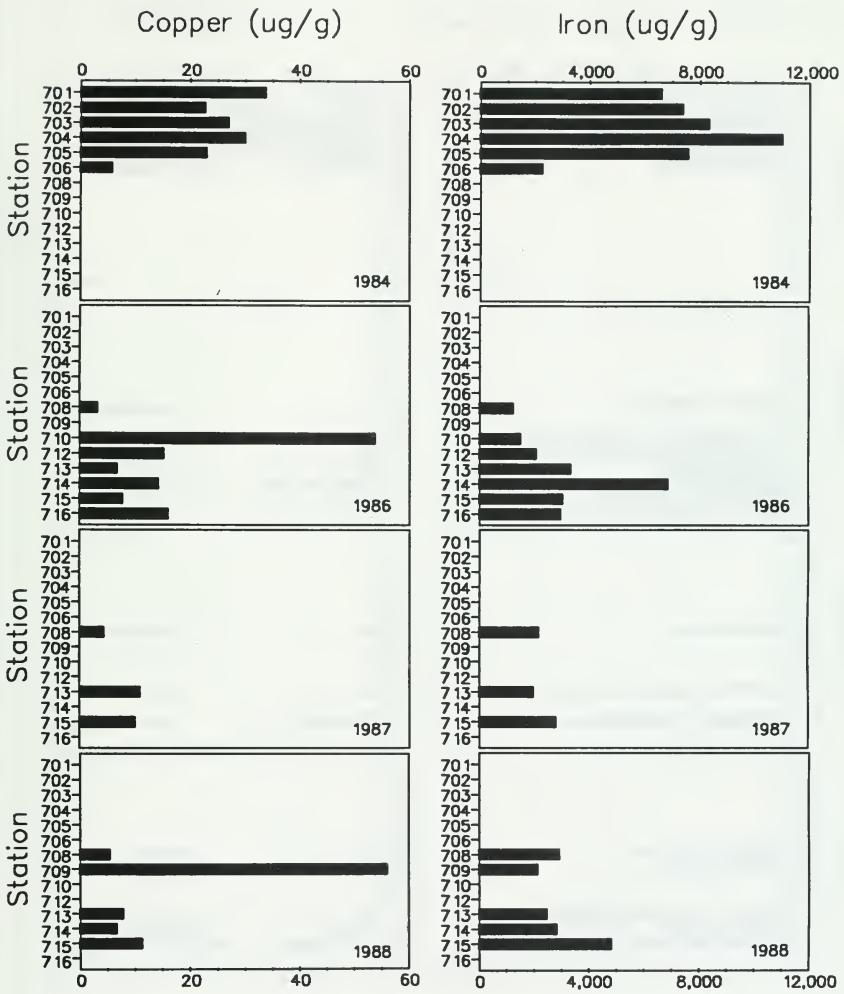


Figure SCR.5: Elemental concentrations in Cladophora collected from the St. Clair River.

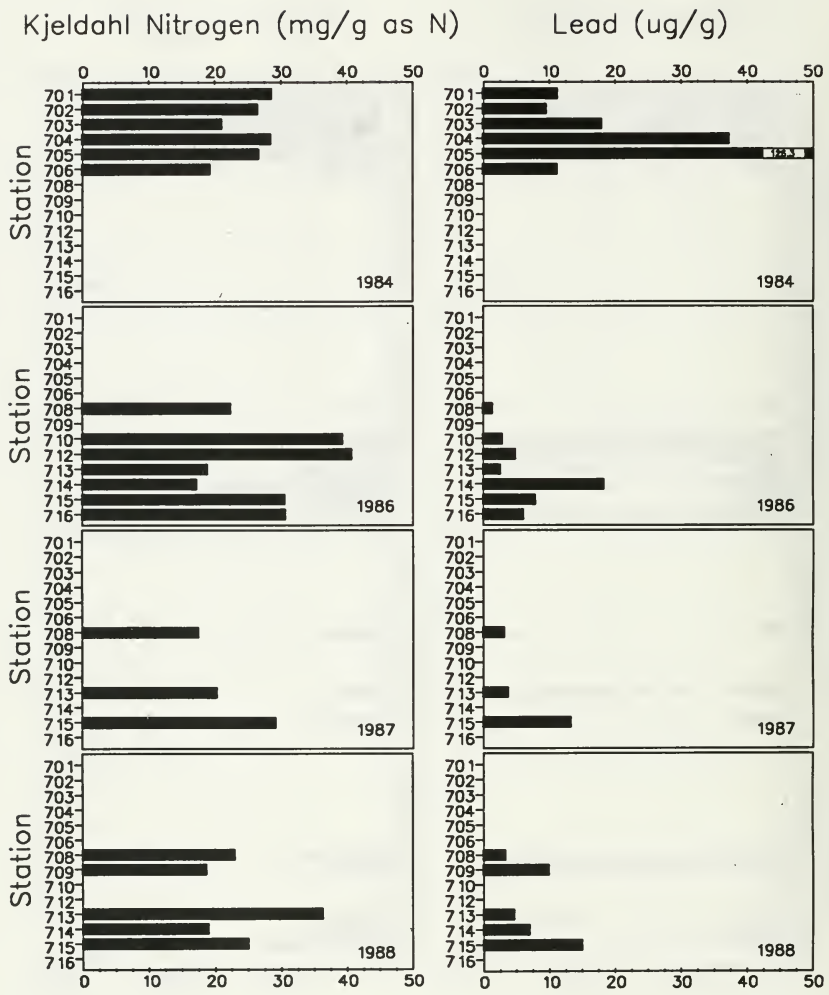


Figure SCR.6: Elemental concentrations in Cladophora collected from the St. Clair River.

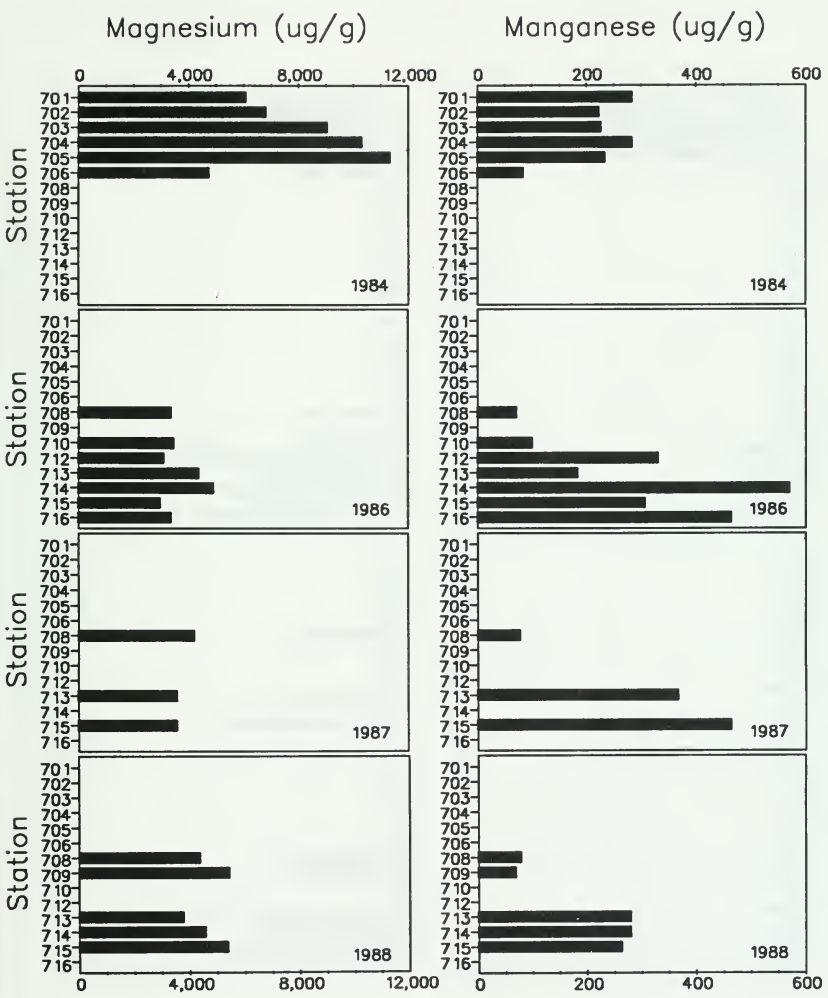


Figure SCR.7: Elemental concentrations in Cladophora collected from the St. Clair River.

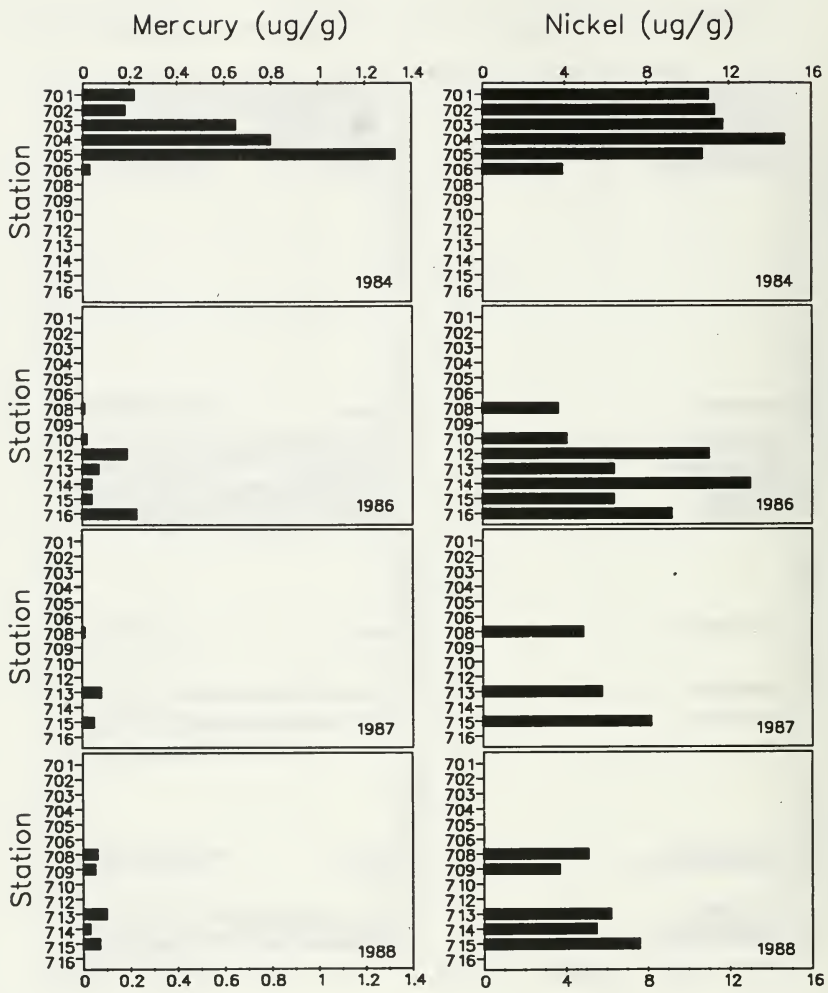


Figure SCR.8: Elemental concentrations in Cladophora collected from the St. Clair River.

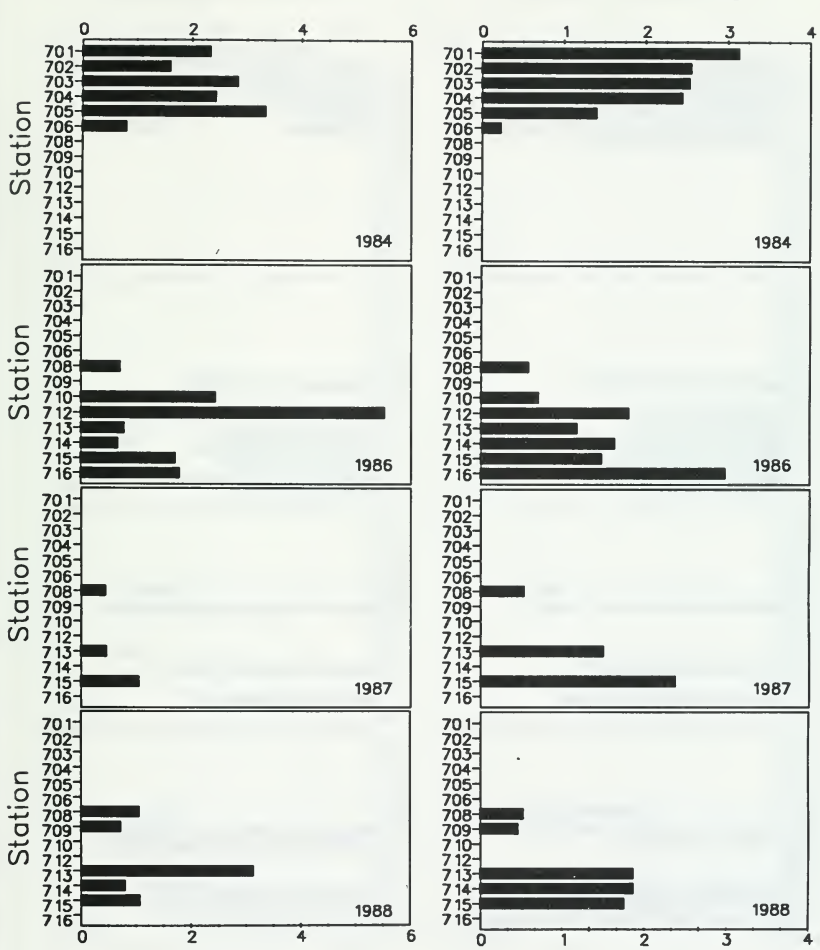


Figure SCR.9: Elemental concentrations in Cladophora collected from the St. Clair River.

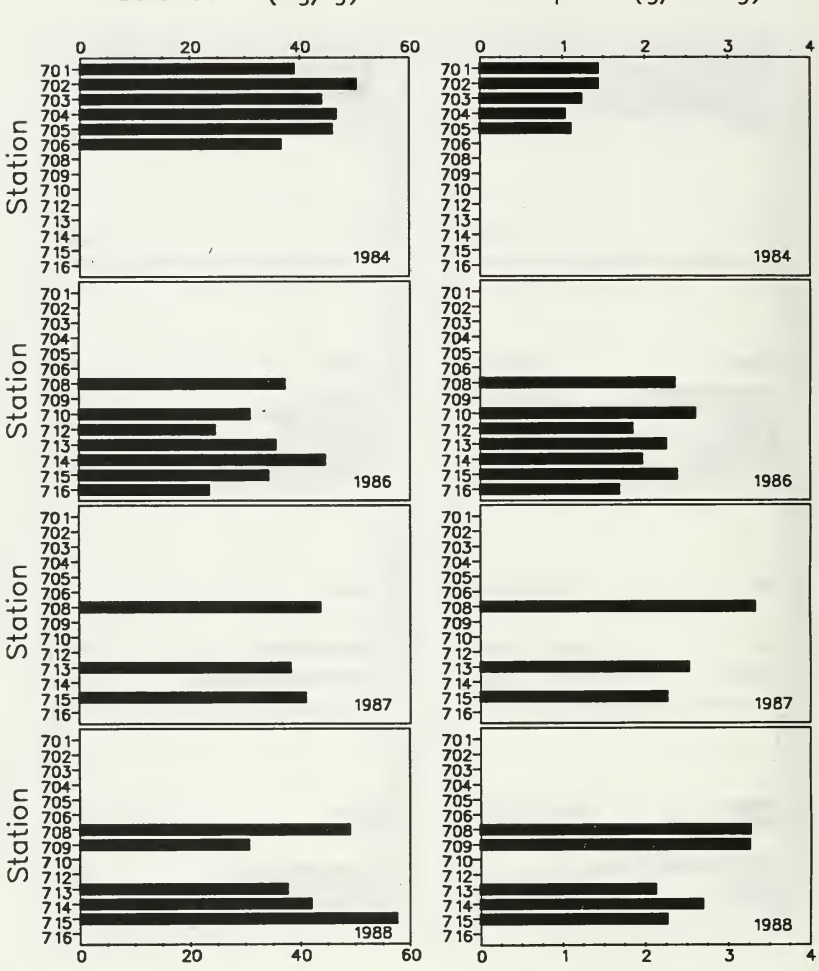


Figure SCR.10: Elemental concentrations in Cladophora collected from the St. Clair River.

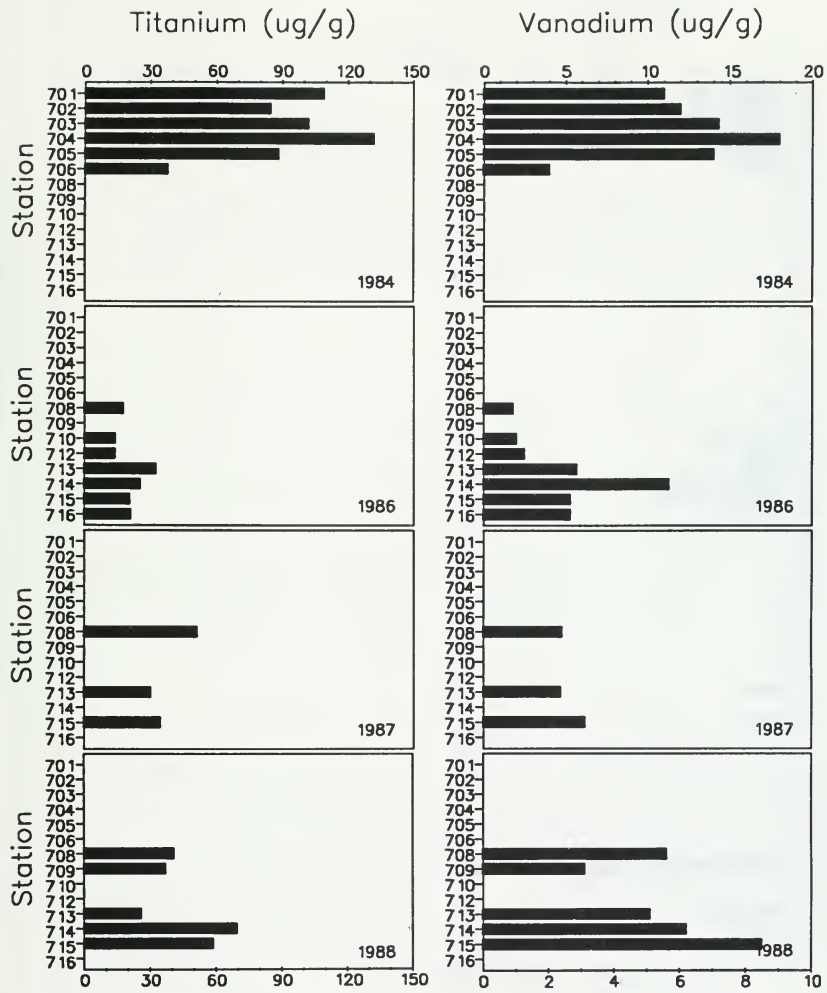


Figure SCR.11: Elemental concentrations in Cladophora collected from the St. Clair River.

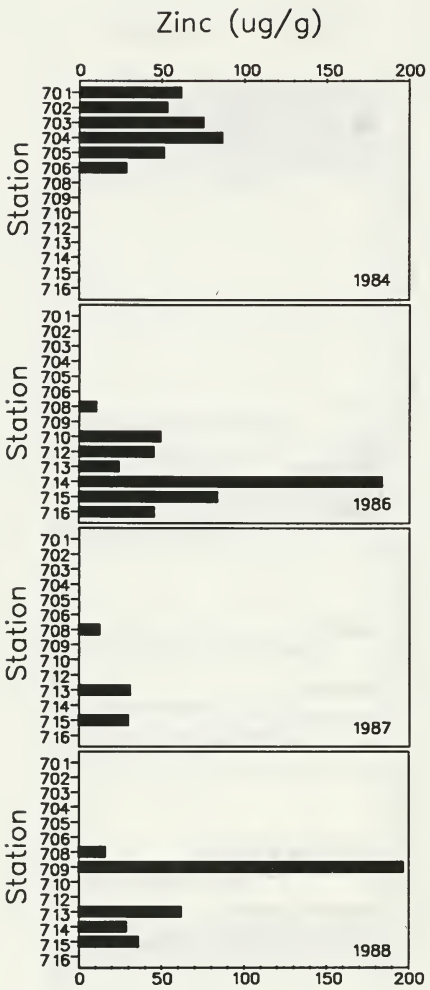


Figure SCR.12: Elemental concentrations in Cladophora collected from the St. Clair River.

VII. Collingwood Harbour, 800 Series:

Elemental concentrations in *Cladophora* collected from Collingwood Harbour at stations 801-811, for the year 1986.

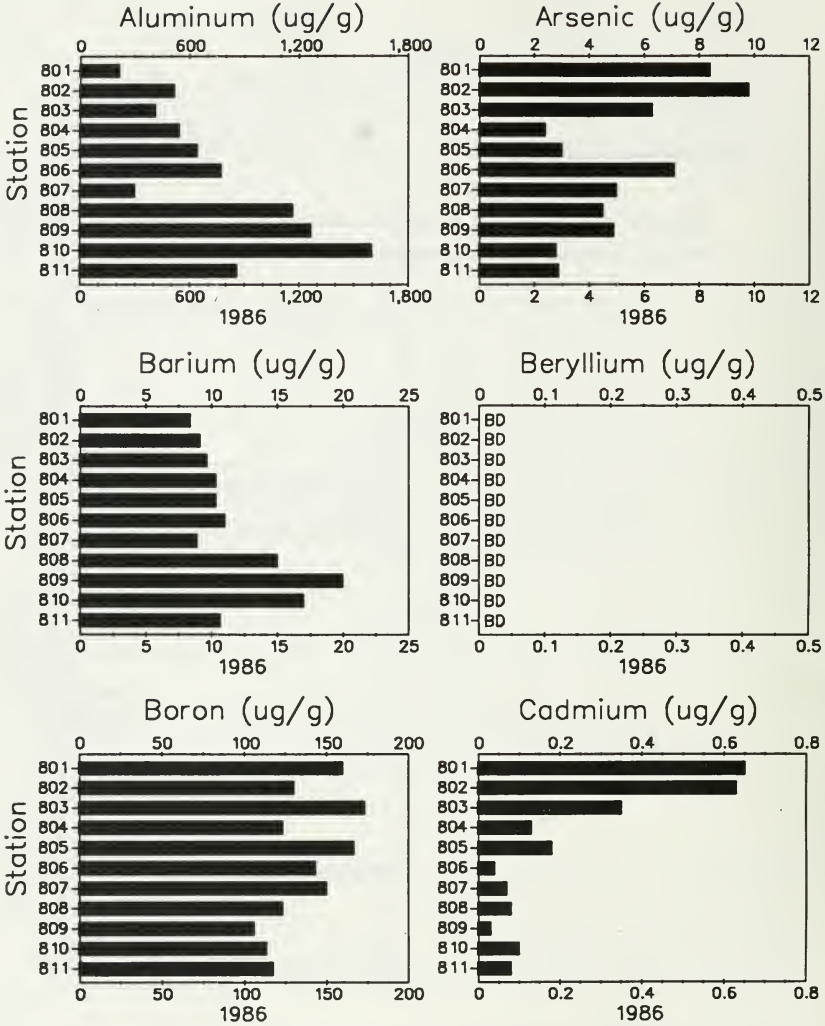


Figure Col. 1: Elemental concentrations in Cladophora collected from Collingwood Harbour

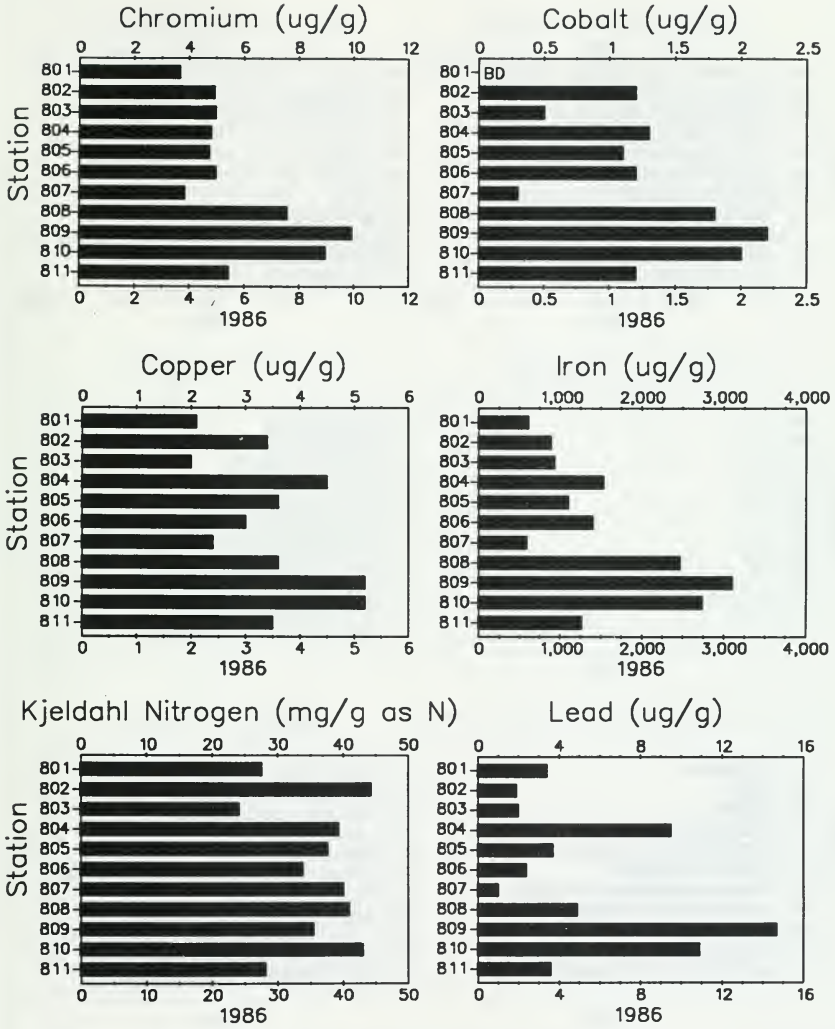


Figure Col.2: Elemental concentrations in Cladophora collected from Collingwood Harbour

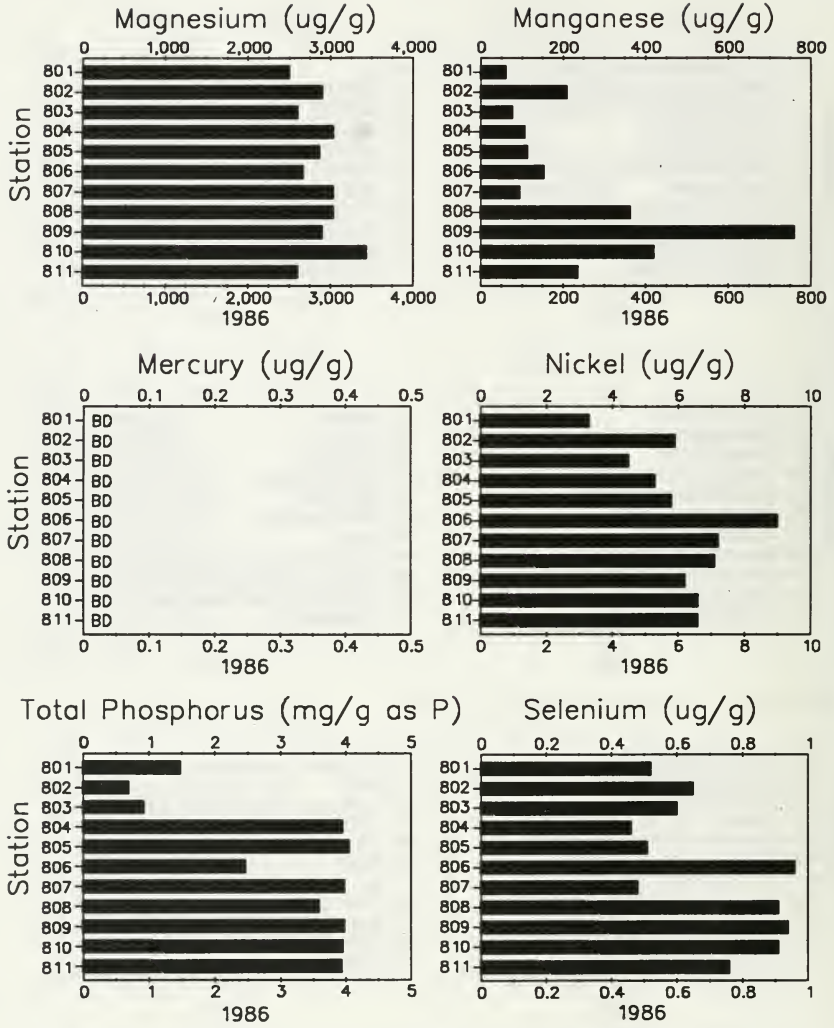


Figure Col.3: Elemental concentrations in Cladophora collected from Collingwood Harbour

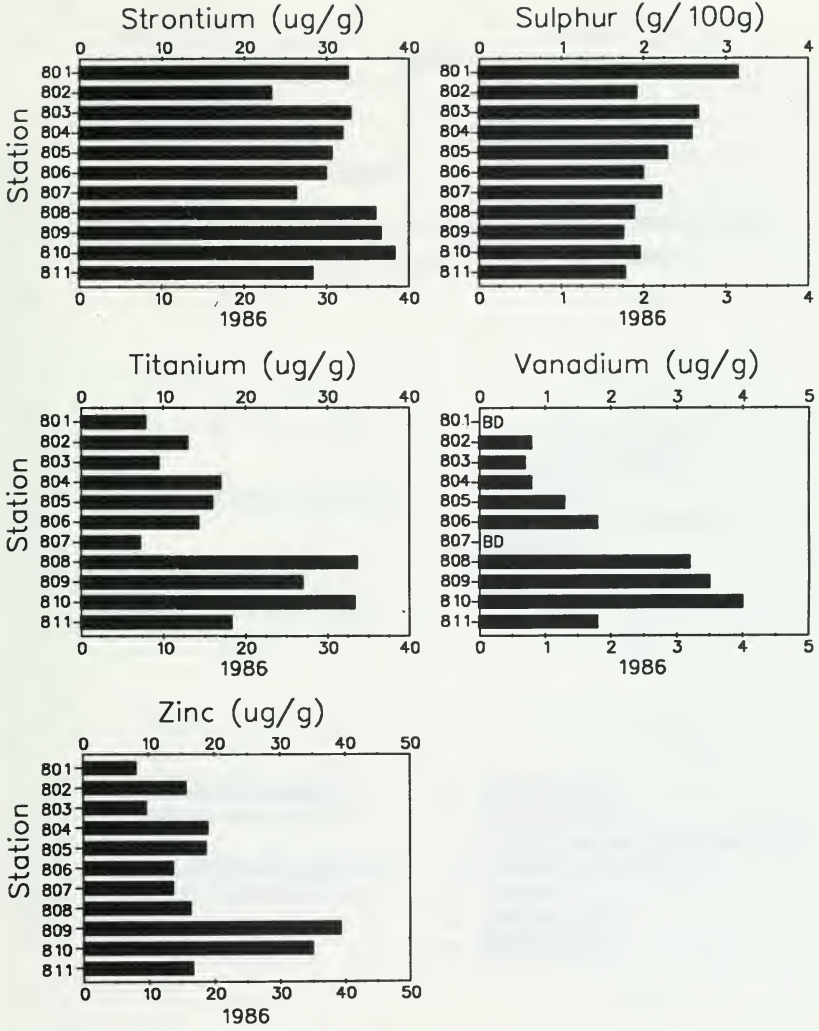


Figure Col.4: Elemental concentrations in Cladophora collected from Collingwood Harbour

VIII. Grand River, 900 Series:

Elemental concentrations in *Cladophora* collected from Grand River at stations 901, 903-908, for the year 1986.

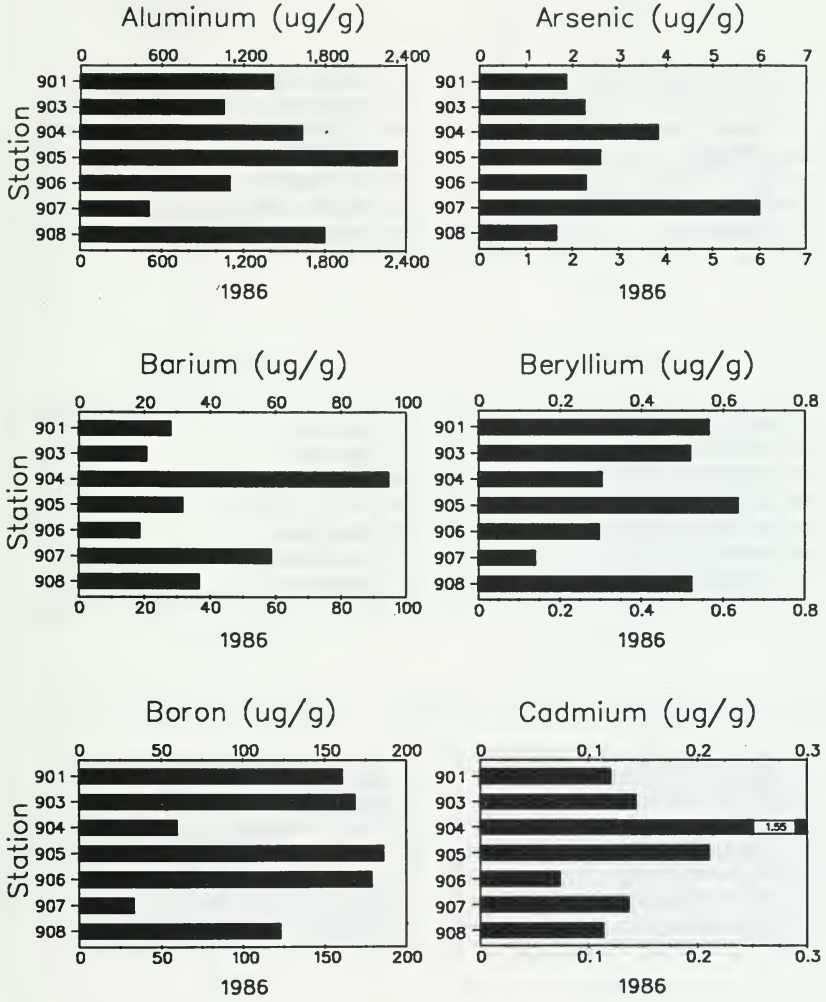


Figure Grd. 1: Elemental concentrations in Cladophora collected from the Grand River.

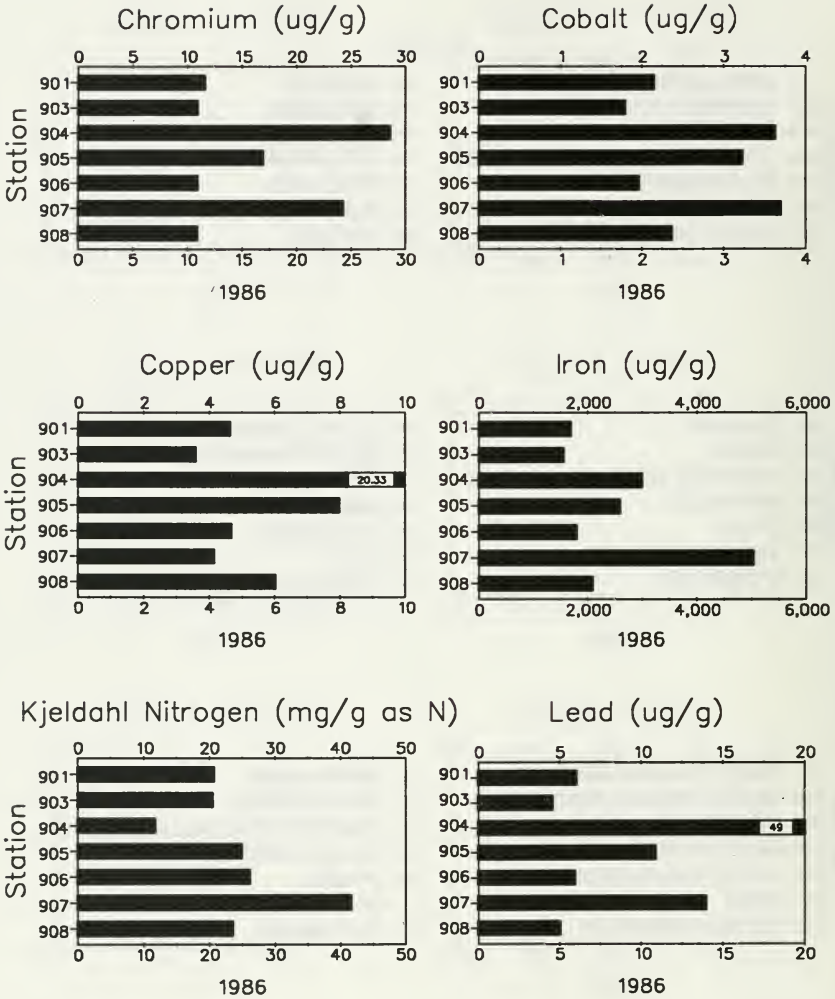


Figure Grd.2: Elemental concentrations in Cladophora collected from the Grand River.

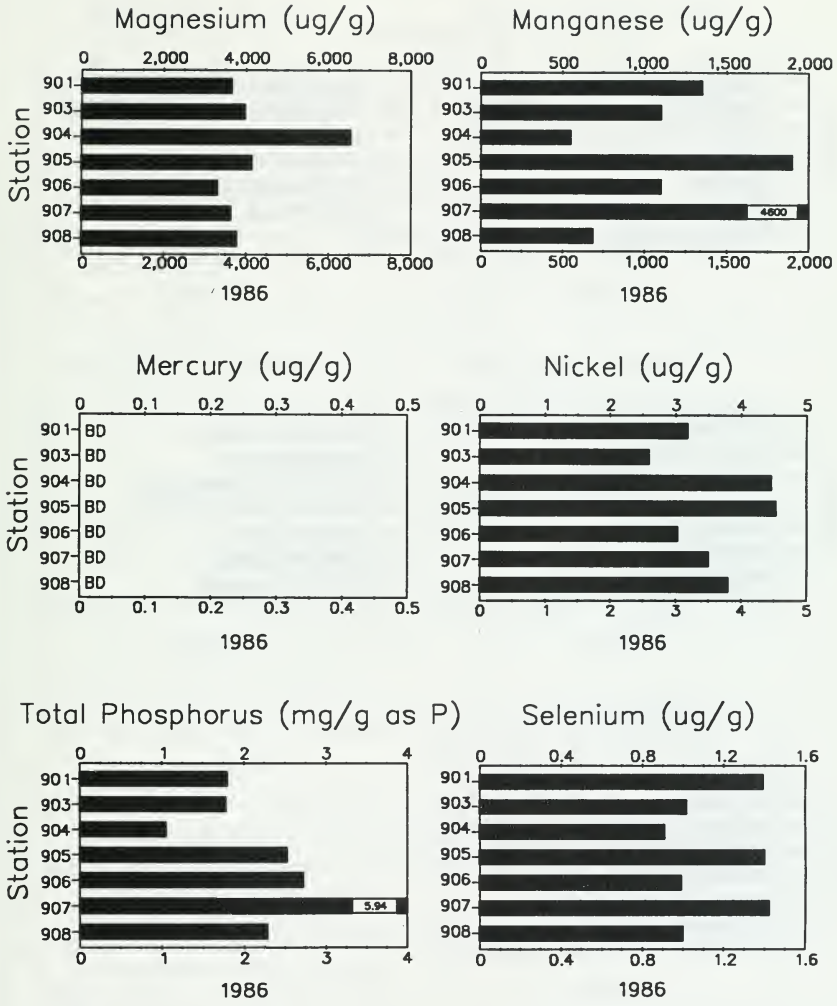


Figure Grd.3: Elemental concentrations in Cladophora collected from the Grand River.

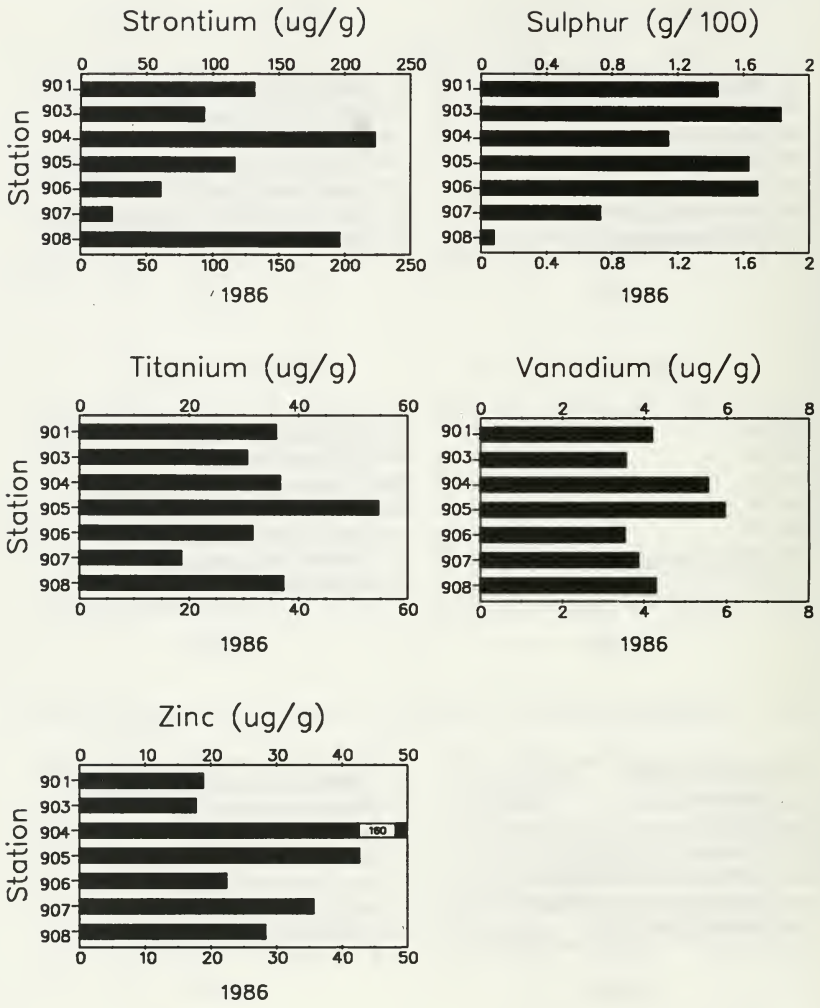


Figure Grd.4: Elemental concentrations in Cladophora collected from the Grand River.

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Appendix I: Results of Triplicate Analyses Showing the Arithmetic Means ± 1 Standard Deviation at Station 415, in the Niagara River, Characterized by High Concentrations of Contaminants in *Cladophora* Samples

Date of Collection	Aluminum µg/g dry as Al	Arsenic µg/g dry as As	Barium µg/g dry as Ba	Berylium µg/g dry as Be	Boron µg/g dry as B	Cadmium µg/g dry as Cd	Chromium µg/g dry as Cr	Cobalt µg/g dry as Co	Copper µg/g dry as Cu	Iron µg/g dry as Fe
87–06–18	3733±907	3.8±0.4	44±2	0.51±0.03	363±12	0.65±0.03	13±1	4.0±0.1	18±1	5133±208
88–06–21	4433±862	6.5±0.1	39±10	0.57±0.08	280±0	0.73±0.02	14±1	4.9±0.3	38±3	5833±551
89–07–05	8933±929	9.7±0.3	36±5	1.07±0.06	96±5	0.96±0.05	28±1	7.4±0.4	44±2	16000±0

Date of Collection	Total K'dahl–N mg/g dry as N	Lead µg/g dry as Pb	Magnesim µg/g dry as Mg	Manganse µg/g dry as Mn	Mercury µg/g dry as Hg	Nickel µg/g dry as Ni	Phosphor mg/g dry as P	Selenium µg/g dry as Se	Strontium µg/g dry as Sr	Sulphur (g/100g) as S
87–06–18	21.3±0.8	17±1	3967±252	467±15	0.63±0.02	9.7±0.2	0.57±0.10	2.5±0.1	85±3	
88–06–21	20.3±3.5	23±1	5000±265	1400±0	1.23±0.23	13.7±0.6	1.30±0.10	4.3±0.9	59±1	1.9±0.1
89–07–05	20.7±2.1	45±8	9267±208	807±12	3.80±0.53	21.7±0.6	1.70±0.10	3.0±1.2	70±1	1.4±0.2

Appendix I: cont.

Date of Collection	Titanium µg/g dry as Ti	Vanadium µg/g dry as V	Zinc µg/g dry as Zn
87-06-18	57±10	7.5±1.6	72±2
88-06-21	66±16	10.0±2.1	99±1
89-07-05		20.3±2.3	250±10

Appendix II: Results of Triplicate Analyses Showing the Arithmetic Means ± 1 Standard Deviation at Station 402, in the Niagara River, Characterized by Low Concentrations of Contaminants in *Cladophora* Samples

Date of Collection	Aluminum µg/g dry as Al	Arsenic µg/g dry as As	Barium µg/g dry as Ba	Berylium µg/g dry as Be	Boron µg/g dry as B	Cadmium µg/g dry as Cd	Chromium µg/g dry as Cr	Cobalt µg/g dry as Co	Copper µg/g dry as Cu	Iron µg/g dry as Fe
87–06–18	940±246	7.8±0.3	22±1	0.00±0.00	227±6	0.18±0.09	5±0	1.5±0.0	4±0	1233±58
88–06–22	2500±721	10.7±0.6	21±2	0.26±0.07	263±6	0.85±0.08	7±1	2.4±0.1	9±2	3433±115
89–07–04	933±99	22.3±1.5	10±1	0.10±0.00	150±10	0.49±0.03	0±0	0.0±0.1	0±0	0±0

Date of Collection	Total K'dahl–N mg/g dry as N	Lead µg/g dry as Pb	Magnesim µg/g dry as Mg	Manganse µg/g dry as Mn	Mercury µg/g dry as Hg	Nickel µg/g dry as Ni	Phosphor mg/g dry as P	Selenium µg/g dry as Se	Strontium µg/g dry as Sr	Sulphur (g/100g) as S
87–06–18	28.0±1.9	2±1	2300±0	100±0	0.02±0.01	4.8±0.4	1.05±0.08	0.7±0.1	81±2	0.0±0.0
88–06–22	24.7±0.6	7±1	3767±115	213±6	0.01±0.01	10.1±0.8	1.70±0.00	1.5±0.1	51±2	2.6±0.1
89–07–04	59.3±9.5	2±1	2733±231	157±6	0.00±0.00	3.8±0.2	4.13±0.85	0.6±0.0	41±1	5.2±0.2

Appendix II: cont.

Date of Collection	Titanium µg/g dry as Ti	Vanadium µg/g dry as V	Zinc µg/g dry as Zn
87–06–18	18±1	2.0±0.4	17±0
88–06–22	39±9	5.6±1.7	42±0
89–07–04	0±0	2.0±0.2	36±1